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LONDON

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THE

ORGANIZATION OF TRILOBITES,

DEDUCED FROM THEIR LIVING AFFINITIES:

WITH A

Systematic Review of the Species hitherto described.

BY

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EDITED FROM THE GERMAN,

BY

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AND

PROFESSOR E. FORBES, F.R.S.

LONDON:

PRINTED FOR THE RAY SOCIETY.

M.DCCC.XLVI.

PRINTED BY C. AND J. ADLARD, BARTHOLOMEW CLOSE.

The Treatise on the Organization and Classification of Trilobites, by Professor Burmeister, now presented to the members of the Ray Society, is not merely a translation of the original German edition published at Berlin in 1843, but a new edition, revised, augmented, and in part rewritten by the distinguished Author himself, who has most kindly endeavoured to render the Ray version as complete as possible by embodying all the information which had accumulated since the publication of the German edition. Through the aid of Professor Burmeister the Society has been enabled to procure impressions from the original and very beautiful plates. These have also been revised by the Author, and several important figures added.

The translation has been executed, under the superintendence of the Editors, by Dr. Hermann Mix. In the revision of the first section of the work, they have been kindly assisted by Professor Ansted.

The translation, especially of the systematic part, is nearly a literal one; such being, in the opinion of the Editors, most likely to convey the sense of the Author, although elegance of expression may occasionally have thereby been sacrificed. They have carefully abstained from altering any expression of the Author's meaning, and even where they might dissent from his views, have preferred silence to the intrusion of their own opinions. The notes they have added are all of an explanatory or supplementary nature, and especially such as may prove useful to the English reader.

The Editors feel that they need not dwell on the great importance of the volume which has been committed to their charge. As a dissertation on a most difficult tribe of fossil Articulata by an eminent Zoologist, deeply versed in the organization of the great class to which it belongs, the work assumes an importance which can rarely be accorded to palæontological essays treating of the remains of Invertebrate Animals.

THOMAS BELL,
EDWARD FORBES.

London; *December* 1846.

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PREFACE.

Having given a sketch of the plan of my present work in the subsequent introduction, it will be superfluous to enlarge further upon it here. My treatment of this subject in a merely zoological point of view is partly owing to the very natural consideration that these most ancient remains of the animal world not only admit of such a mode of contemplation, but, indeed, demand it, if the subject is to be thoroughly worked out; but partly also no doubt it is to be attributed to the entirely zoological direction of my studies. Works on fossils are undoubtedly the more profound, the more the author has penetrated into the study both of Geology and Zoology; but who, excepting Cuvier, can boast of such a universality? I therefore preferred to relinquish the geological investigation of the subject entirely, and not enlarge on the various strata containing Trilobites, and I would also request the reader not to lay any great weight on the geological observations he will occasionally meet with in the course of the work; for they may sometimes have been based on the views of others imperfectly understood, and for this and other reasons they must be considered as not to be implicitly relied on. On the other hand, I would venture to hope, that my zoological system of arranging the various groups may meet with the approbation of my readers, and that I may have succeeded in my endeavours to lay the foundation of a single and correct view of the subject, which may supersede the many fluctuating ones hitherto prevailing. My object indeed included both these departments of the subject, but I cannot answer for the correct designation of many specimens supposed to be of identical species, but frequently no doubt imperfectly determined, or of others presumed to be new, the originals of which I was not permitted to examine. I have indeed received much assistance from German authors, but have often not been so fortunate with regard to those whose species appeared to me the most questionable, and in such cases the determination was frequently left to the view I took of them on my own personal inspection. I have seen everything connected with my object contained in the collections of Berlin and Halle, and I have also received valuable contributions from Mr. Boecksch in Silesia, from Captain von Charpentier, and from Mr. Höninghaus at Crefeld. On the other

hand, I have had but few opportunities of examining original specimens from England and America. My present work therefore certainly ought not to be considered as complete; it will unquestionably admit of much improvement, and for this purpose I should gratefully receive any assistance, especially of original specimens of species hitherto unknown to me, even if it were only for temporary inspection. Indeed I should be satisfied with good figures of such specimens, provided they were accompanied by explanatory descriptions. Such illustrations being rare, I have made it my principal object to render the plates contained in this work as perfect as possible. I have had the good fortune to meet with an artist in the person of Mr. A. Andorff, of Berlin, whose talents and whose execution of the engravings are such, that I can, without the slightest hesitation, recommend the plates, which were executed by him, as patterns for imitation to all artists. Every person acquainted with the subject will undoubtedly agree with me, that better and more beautiful representations of Trilobites, or figures more true to nature in every respect, are not in existence.

HALLE; *May 8th*, 1843.

INTRODUCTION.

SECTION I.

Researches on organic bodies of former ages are equally interesting and necessary to the Zoologist and Geologist, although their respective objects in pursuing such studies are different. For whilst the Geologist is generally satisfied with establishing the difference or identity of the species found in the several strata, the Zoologist insists rather on a perfect knowledge of the animal in question, to enable him thereby to determine the modifications which the entire animal organization has experienced in the successive periods of the earth's formation.

These entirely different interests of the observers explain in some measure why the knowledge of extinct animals necessarily remained in a defective and imperfect state so long as no competent Zoologist occupied himself with the subject, and indeed, even a Zoologist who is so qualified can only give satisfactory information if perfectly acquainted with the organization of the living allies of such animals, and that in most minute detail. This indeed is sufficiently proved by Cuvier's great researches in the department of Palæozoology, and the example of this great man has led modern Geologists who study fossils to the conviction of the necessity of profound zoological studies, and has convinced them that an investigation, at least of the higher animals, cannot be instituted without accurate zoological knowledge. The truth of this principle has, however, been less acknowledged with regard to the lower animals, and least of all with respect to the Articulata, because their number and importance in relation to geology is, upon the whole, comparatively slight, whilst their organization also has been particularly studied only by a few Zoologists, and by them only recently. There is no family, however, among the Articulata of a former world which in every respect deserves so much attention as the family of the *Trilobites*: and consequently this tribe has been the subject of much research, but our acquaintance with their organization is still very defective, either because all the more recent observers, from a consciousness of their imperfect knowledge, did not enter into the study of them in a zoological point of view; or because, from the deficiency of their zoological studies, they could not, on attempting to do so, disguise their ignorance on those points. And yet it is undeniable that we may obtain as clear and perfect an acquaintance with the organization of these creatures as of the Mammalia, since the organization of a crustacean being evidently less complex than that of a mammal, a perfect idea may be developed with even greater completeness from the existing fragments of the Trilobites, than was possible in Cuvier's representation of the Vertebrata.

SECTION II.

The object of the present work is the carrying out such an illustration of the subject in all its parts. Having almost exclusively occupied myself with the study of the Articulata, especially of insects and crustaceous animals, I have collected the materials upon which I based my undertaking with diligence and circumspection; I have most carefully tested all analogies as well as more remote relations; I have frequently consulted with my friends; and I have thus gradually progressed with my subject until the present moment, when leisure is at last afforded to me to devote myself entirely to the work, and to present it to the public in its present state.

Previous, however, to communicating my own researches, I beg to lay before my readers a short sketch of the information which has hitherto been known respecting the Trilobites.

SECTION III.

The first author who wrote on these remarkable animals was Edward Lhwyd, Curator of the Ashmolean Museum at Oxford. He discovered two fragments and one entirely preserved specimen of the *Oggygia Buchii*, near Llandeilo, in Carmarthenshire, of which he sent drawings to the well-known zoologist Martin Lister, also a superintendent of the Ashmolean Museum. The latter gave them to the public in the twentieth volume of the 'Philosophical Transactions.' Lhwyd owns in his letter that he did not know what to make of these fragments; in Fig. 8 of the accompanying plate we recognize, however, with tolerable certainty, a cephalic shield of the genus *Trinucleus* of Murchison, (*Cryptolithus*, Green,) and the *Oggygia* (Fig. 15) is perfectly evident; but Lhwyd explains it to be the skeleton of an unknown fish. The same author published in the year following his 'Ichnographia Lithophyl. Britann.,' and therein enumerates thirty specimens already observed by him; but those before alluded to are again mentioned, the first under the name of *Trinucleus fimbriatus vulgaris*, the subsequent Dudley fossil as *Buglossa curta strigosa*. These communications, the earliest we possess on the Trilobites, were soon followed by others in all parts of Europe, but although the number of observations was thus increased, the knowledge of these animals made no progress, principally because correct comparisons with living forms were wanting. They therefore appear in subsequent authors merely under newly-invented names, which partially indicate very incorrect comparisons, the inappropriateness of which is, however, excusable, since the observers of the Continent were only acquainted with mutilated specimens, or with mere caudal shields, and therefore were much inclined to mistake these remains for shells. One author (Hermann) calls them *Pectunculites trilobus imbricatus*, another (Scheuchzer) compares them with *Patella*, a third (Bromell) fancied that he recognized in them the remains of insects, while a fourth (Brückmann) also compares them with shells, calling them *Armata veneris*, and so also does Waltersdorf, who, in his System of Minerals, styles them *Conchites trilobus*, connecting together the different designations of his predecessors in "Käfermuschela," and "Muschelsteine." But the correct view of the natural affinity of the Trilobites was announced at almost the same period. Their anomalous form induced a

number of collectors to search for them in England, where the most beautiful and perfect specimens have always been found, and their admirable condition in that country readily caused the impression that they must be Articulata to gain ground. We learn from Dr. Shaw, Lister's successor in Oxford, that he took them for a caterpillar (eruca), and Ch. Lyttleton, who laid new specimens before the Royal Society of London, coincides in this view; Ch. Mortimer, on the other hand, on an occasion of some new specimens of the Dudley fossil (as the Trilobites were usually called in England, from the principal locality where they were found) having been sent by Dr. Pocock, expressed the opinion that they appeared to correspond most with the *Monoculus apus*, Linn., shortly before described by J. Th. Klein, in the 'Transactions of the Royal Society' (vol. xl, p. 150). As Klein had given the name of *Scolopendra aquatica scutata* to this animal, Mortimer proposed the designation of *Scolopendræ aquaticæ scutatæ affine animal petrificatum*, which, however, even on account of its length, could not meet with any great approbation. The next English author on the Trilobites, Emanuel Mendez Da Costa, endeavoured therefore to find a better name, and on again laying a beautifully preserved specimen before the Royal Society, he declared it not only to be a crustaceous animal, but also to be one nearly related to the sea-louse, and he called it *Pediculus marinus major trilobus*. This name of sea-louse was then employed to designate several of the larger *Isopodes*, which live on fishes as parasites, and from amongst which Linnæus constituted his genus *Oniscus*. Linnæus, whose system and reform of the science just then began to be appreciated, had consulted with Mendez Da Costa respecting the Trilobites in the same year, and designated all the species belonging to it as modifications of his *Entomolithus paradoxus*, deciding himself in favour of their near affinity to *Monoculus apus*. This view of the great naturalist, which is expressed in all the editions of the 'Systema Naturæ,' certainly ought to have led those who knew little more of the subject than the fragments lying before them to a correct conception of the affinity; but their very ignorance of the points of comparison made them overlook it. Several authorities now again declared in favour of the affinity to the *Mollusca*; but the French observer Guettard correctly enumerated the Trilobites of Angers among the Crustacea, designating them as allied to the genus *Oniscus* of Linnæus. This author was, however, perfectly unacquainted with Linnæus, and equally so with the German writers, who also have never taken any notice of him. The next writer on the subject, Father Joseph Torrubia, having been a native of Spain, where the sciences were in a dormant state, I shall not lay any great stress upon his opinion, but he at first correctly described the Trilobites as crustaceous animals, although subsequently, misled by the inspection of Rumphius's figure of the *Limæ marina* (*Chiton aculeatus*, Linn.), imagined the latter to be a mollusc. The treatises of the Provost Genzmer of Stargard, of Professor D. J. G. Lehmann of Petersburg, of the well-known secretary of the town-council of Danzig, J. Th. Klein, and of Professor Zeno of Prague, I may enumerate as proofs that such an erroneous conception of the nature of Trilobites has prevailed. The first termed them *Conchitæ rugosi trilobi*, and Lehmann,* as also Klein, adopted this designation, whilst their contemporaries enumerate them by the names of "Käfer-muschel," and "Kakadumuschel." This determined another, but more enlightened

* In the summary of this volume, p. 56, the author expresses the same opinion as Linnæus, without, however, guaranteeing its correctness.

collector to endeavour to diffuse Linnæus's views respecting the true affinity of the Trilobites among his readers, and to prove "that the Conchologists have no longer any reason to consider the fossil which had hitherto been known by the name of a *Conchitæ trilobi rugosi* as a part of their science." The author of the treatise referred to, Ch. Fr. Wilkens, announced his name in the following year, and published his opinions under the title of 'Information respecting Rare Animal Petrifactions.' He treats of the numerous Trilobites in his collection with much cleverness, although with an unnecessary prolixity, and arrives finally at the well-founded result, that the name of *Entomolithus branchiopodis cancriformis marinus* ought to be given to them. But the appearance of this treatise in an unknown periodical, was not calculated to attract attention, or procure credit and appreciation for it, and it is questionable whether it would ever have come to the knowledge of subsequent authors, if J. Imm. Walch had not particularly referred to it in his 'Natural History of Fossils.' It decided Walch's opinion, however, and as this diligent writer brought together everything that had hitherto been written on the Trilobites, his elaborate work became an authority on which succeeding authors might rely with certainty in the labyrinth of conflicting opinions. Being convinced of the unfitness of the names hitherto used, either owing to their incorrectness or their length, he proposed a new designation for them, and was the first who called these animals *Trilobites*, a designation, which, with the exception of Dalman, has been retained by all the subsequent authors, and therefore, being the oldest and by no means an unsuitable name, will also be retained by us. Walch, however, was not sufficiently a practical zoologist to be able to support Wilkens's views by additional reasons, and indeed he generally speaks more of the ideas of others than of his own opinions on the subject, and seems inclined to consider the *Ouisci* as the animals most nearly allied to the *Trilobites*. Henceforth the opinion of the affinity of the Trilobites with the *Mollusca* was nearly buried in oblivion, and would probably never have been known, if its memory had not been revived again nearly fifty years afterwards by a zoologist, from whom, possessing as he did an accurate knowledge of the Articulata, one could least of all have expected it, namely, by Latreille. The next writer after Walch, John Beckmann, calls them *Ouisci*, without any circumlocution, and Count v. Kinsky, in a letter to the Baron von Born, uses the name given by Linnæus, while M. Th. Brunich, on the other hand, uses *Trilobus*, Walch's designation in an abbreviated form, and J. K. Gehler retains it in its original form. Finally, the opinion of A. Modeer, who thought that he could recognize the structure of a tube beetle, (*Coccinella*) in the Trilobites, at least in the heads of *Battus* and *Olenus*, which he described, was new but erroneous.

SECTION IV.

Such was the state of our knowledge of the *Trilobites*, when the great political events which took place at the conclusion of the last and the commencement of the present century rendered all serious efforts for the advance of science impossible. During the period extending from 1793 to 1820, we only meet with three short observations on the Trilobites, of which the first is contained in Blumenbach's 'Illustrations of Natural History;' the second in Parkinson's 'Organic Remains of a Former World;' the third in Leonhard's 'Taschen-buch fur Mineralogie;' in which the Baron v. Schlotheim describes a new series

of Trilobites as *T. cornigerus*, directing attention, according to Beckmann's and Brünich's example, to the necessity of distinguishing several species of these animals. This very correct view he further carried out in his 'Petrefaktenkunde' of 1820, in which he speaks of five different species, two of which, however, belong to doubtful forms. All the three authors are of opinion that the Trilobites are Crustacea, without, however, determining their more intimate affinity with any particular group.

SECTION V.

The year 1821 is a crisis in the literary history of the Trilobites, for a new epoch then commences, which may be designated as the period of the more accurate study of them. Four distinguished observers, Latreille, Audouin, Wahlenberg, and Brongniart, published the result of their studies in or immediately after this period, the two former only paying regard to the organization of these animals, the two latter describing the differences of the species.

P. A. Latreille, the best authority on the subject of the Articulata, both with respect to the general subject and its details, might certainly claim attention to his opinion on the affinity of the Trilobites; but he performed his task in a manner which could by no means satisfy those acquainted with the subject. After having formerly determined in favour of the affinity of the Trilobites to the Articulata (Cuv. Règne Anim., prem. ed. tom. iii), he here contradicts this opinion altogether, and endeavours to prove, by the absence of feet, that the Trilobites must be most nearly related to *Chiton*. He not only, therefore, overlooked the articulation of the body, pervading all parts of it, but also the eyes; he asserts also, that if feet had been existing they must be recognizable, and from their absence draws the conclusion that the Trilobites are Mollusca.

V. Audouin, who probably had only shortly before completed his work on the skeleton of the Articulata (Annal. des Scienc. Natur., pr. ed. tom. i, 1824), had also been led by these studies to the subject of the Trilobites, and soon recognized their articulate nature from the remains of the crust. But he evidently went too far in transferring the results he had so readily arrived at with regard to insects to the other groups of the Articulata, and in this he sought analogies which do not exist in reality. Indeed, even his own investigations with regard to the abdomen of the *Macrura*, with which, as with the thorax of the *Isopoda*, he very justly compares the crust of the Trilobites, ought to have convinced him that the *episterna* and *epimera*, two portions of the thorax of insects which are separated by particular sutures, do not at all exist in the groups enumerated, and that even the boundary between back and sternum is an artificial one. He nevertheless views the lateral lobes of the shell, which in many of the Trilobites are separated by an oblique diagonal furrow into an anterior and posterior half, as analogues of those parts, terming the anterior *episternum*, the posterior *epimerum*, and the middle part of each *tergum;* appellations manifestly unsuitable, since several Trilobites (e. g. *Illænus*) do not possess this separating furrow at all, and in no single species of them do the regions distinguished by him constitute isolated pieces connected by sutures. We arrive, however, in spite of these subtleties, for which there is no natural foundation, at the four following facts, namely,—

1st. That Trilobites differ only from the other *Articulata* in points of secondary importance, and that, beyond a doubt, they belong to this group of the animal kingdom.

2dly. That they exhibit the greatest analogies with the *Isopodes*, particularly with *Cymothoa* and *Ligia*.

3dly. That the want of feet seems to be a necessary characteristic of their skeleton formation, although this point still remains problematical.

4thly. That these feet, if they existed at all, were most probably connected with the branchial apparatus.

An important result was evidently gained by the enunciation and establishment of these four principles, and the consideration of the last assumption especially has given that direction to future researches which is the proper result of a preliminary investigation.

George Wahlenberg followed more closely the footsteps of Linnæus than any of his predecessors, and endeavoured to maintain his view respecting the affinity of the Trilobites, merely also changing Linnæus's name of *Entomolithus* into *Entomostracites*. But as he was no special zoologist, and as the groups of the Crustacea in general could not be very strictly defined at that period, or their essential characters be readily distinguished from others, he did not succeed in establishing such evidence as should be incontrovertible. He believed that the Trilobites were most nearly allied to *Limulus*, and was inclined to transfer this similarity also to the structure of the feet. The feet of the Trilobites, in his opinion, however, were smaller than those of *Limulus*, and for this reason were absent in the fossils. In some shields and rings he believes that he recognizes mere membranes that had been cast off, there being no doubt that these animals must have cast their membranes in the manner of the Articulata. In other respects he still leaves all the species in one genus, and describes fourteen of them.

The most perfect work of all is Al. Brongniart's 'Histoire Naturelle des Crustacés Fossiles,' which appeared about a year after the publication of Wahlenberg's paper. It was this work which first pointed to the generic differences of the Trilobites, exhibiting five genera mostly well-distinguished; the species were more accurately determined, and the number then known was stated to be seventeen; finally, there were here explained many facts with regard to the geological history of Trilobites more elaborately than had been done by Wahlenberg.

Brongniart expresses the correct view with reference to the zoological relations, namely, that the Trilobites are most nearly related to the *Branchiopodes* among the Crustacea, and that the want of visible feet, as well as of visible antennæ, accords very well with this. He does not, however, dispute the analogy with the *Isopodes* so distinctly as the subject requires. The importance and influence of this excellent work on our knowledge of the Trilobites was exhibited immediately after its appearance, since M. Schlotheim felt himself obliged to publish an addition on this subject as a supplement to the former scanty results of his 'Treatise on Fossils;' and in this supplement, in which he gave an extract from Brongniart's work, together with a description of some new species, the number of all the known species, including three which are unsatisfactorily described, amounts, according to his enumeration, to twenty-nine, from which, however, we must omit three, as decidedly not belonging to the family.

SECTION VI.

Having thus traced the history of the Trilobites in detail, and almost completely, I shall now terminate this part of my work, since, after the publication of M. Brongniart's work, the multitude of authors increased with every year, insomuch that a mere enumeration of them would be not only wearisome but superfluous, since the contribution of each individual being merged in the general progress of the study, the latter only requires to be made prominent. We find, however, that the exertions of naturalists henceforward were especially directed to the establishment of species, and to the publication of new forms, and that a variety of errors have been committed in this respect, which principally originated in the defective knowledge of the structure of the body of the Trilobites, and in the imperfect fragments upon which such new species have been founded. An immense number of new names and characters has therefore certainly accumulated, but by no means in the same ratio is the number of really new facts. Even monographists of some districts in which remains of Trilobites are found, have not been able to guard against confounding species already known with supposed new ones. If I were now to enter upon the particular proofs of such errors, it would lead me into an investigation of the differences of species, and thereby cause subsequent repetitions; I limit myself therefore to a short notice of those works which have excited attention, and on that account deserve a particular notice.

Dalman's 'Treatise,' published in 1826, is, next to Brongniart's 'Monography,' the most important work on Trilobites, but it does not add any important new facts in a general point of view, and by no means determines the zoological affinity of the Trilobites decisively. In the particular point of the establishment of species, it is only richer and more complete than Brongniart's work with reference to Sweden. The author's proposal to use the appellation of *Palæades*, instead of the family name of Trilobites, has met with no approbation, nor does it merit such, since nothing more is expressed by it than by the older name, which at least indicates correctly a portion of the family characteristics.

The Trilobites, however, were made the subject of researches at many different places, almost simultaneously with Dalman, and many new forms and views were thereby more intimately explained. Dékay (1824) was the first who described the North American Trilobites in several treatises, but his results were not appreciated by the scientific men of Europe till afterwards. Count Sternberg (in 1825) described the Trilobites of Bohemia with his usual accuracy, and had in Boeck (1827) a successor equally careful and ingenious. It is to the latter that we are particularly indebted for a correct view of the facial line or suture, which extends through the cephalic shield. Payton wrote on the Trilobites at about the same period in England, but I am not able to say with what success, since I have never seen his work. Four authors were within a short time successively employed on this subject in Russia, who furnished by their joint efforts many valuable contributions. Eichwald, the earliest of them (1825), gave a perfect monography of the Trilobites of Esthonia, and also enlarged on their zoological affinities. His endeavour, however, to trace the analogy of the *Trilobites* with the *Isopodes* was not more successful than his establishment of thirteen different species was accurate. After carefully analysing them, we can only recognize in them four really distinct species.

Razoumowsky's observations (1826) are aphoristic, and are limited only to some forms from the neighbourhood of the Ladoga Lake, all of which were already known. Stschegloff's treatise (1827), on the Trilobites of Petersburgh, written in the Russian language, I only know through Pander's work. The latter careful observer treated the same subject (1830) with great minuteness, but without important results. He certainly succeeded in partially reducing Eichwald's species, but he himself mistook his own species, and considered them as new ones, which is not the case with any one of them. The general part of his work exhibits the greatest diligence and research, but it also shows an entire want of knowledge of living Crustacea, owing to which it was impossible for the author to communicate new and certain information on the structure of the Trilobites. Eichwald, Razoumowsky, and Pander, however, also recognized the peculiar swelling at the lower side of the cephalic shield, which lies before the mouth, first observed by Stokes, and which corresponds with the *clypeus* of the Crustacea and Insects. Goldfuss (1828) endeavoured to give information on the feet of the Trilobites, which had hitherto escaped the attention of observers, but although he explained their structure correctly in a theoretical point of view, his illustrations are not calculated to convey the idea they are intended to represent. The endeavours to trace these organs in our fossil remains must always remain unsuccessful, since it is impossible that parts of such a tender nature as we must suppose them to have been, judging from the living analogues of the genus, can have left trace of their existence. Their very absence in fossils most distinctly proves their former real structure.

Next to Pander's work there was published (in 1832) Green's 'Monography of the American Trilobites,' a work abounding in names and words, but as poor in really available facts. Indeed, if the author had not also caused plaster casts of his best specimens to be manufactured, it would have been impossible to recognize even one half of the really new species from his descriptions and illustrations. This period, indeed, was rich in a number of publications on the subject, the appearance of which was of no great importance to the furtherance of our knowledge, and the value of which was very correctly estimated by L. v. Buch, when he considers them as of less consequence than "two important observations of Quenstedt in Wiegmann's Archives," on which I shall soon more particularly enlarge. Among these writers we may enumerate Zenker, the more recent (1833) observer of Bohemian Trilobites, the results of whose labours were already successfully portrayed in the same year by Count Sternberg. Klöden's statements also, respecting the structure and mode of living of the Trilobites on those remains which are found in the Mark Brandenburg (1834) only contain ill-founded assertions. This certainly cannot be asserted of Sar's communications (Isis, 1835), although not all the species are new which he describes as such. We regret that the same may be said of Murchison's description of the English Trilobites, given in his great and excellent work on the 'Silurian System of the British Islands' (London, 1837). The author, being merely a geologist, has preferred allowing W. S. M'Leay to speak on the zoological affinity of these animals, but the peculiar ideas of the latter are not calculated to afford a real explanation of such questions. The division of the *Crustacea*, in which the *Amphipodes* (together with the *Isopodes*), *Trilobites*, and *Entomostraca* are enumerated as three subdivisions of equal value with one great principal group, which is considered as founded in nature, is not calculated to create any great confidence in the systematic talent

of their author. M'Leay, too, on this occasion, as he has often done elsewhere, confounds the ideas of analogy and affinity, the first distinction of which in England is justly considered as his greatest and generally acknowledged merit. Another English author, however, Dr. Buckland, had not long before (1836) already explained the same subject with much genius and vigour. He believes that *Serolis*, *Limulus*, and *Branchipus* are the three genera of living Crustacea, to which the Trilobites are most nearly related, and he founds his comparison on the resemblance of general form in the first, the structure of the cephalic shield in the second, and the structure of the feet and nature in the eyes in the third. How far these assumptions are well founded, we shall subsequently investigate.

I will not here touch at greater length upon the several observations of contemporary writers, as of Hönighaus, Bronn, H. v. Meyer, Hünefeldt, J. V. Thompson, Sowerby, Jukes, Esmark, Green, and Harlan, but will proceed to some more recent, more elaborate, and more important works, which form the conclusion of the researches hitherto made. Hisinger, in his General View of the Swedish Trilobites (1837), the first of these publications, follows Dalman's example exactly, and gives but few new facts. Quenstedt's* statement in Wiegmann's 'Archiv' (1837, 1), deserves greater attention, especially on account of the importance which was here first attached to the numerical proportions in the different divisions of the body, particularly of the trunk. I must, however, dispute the correctness of the author's representation of the eyes, of which he assumes two types, and also his assertion that a division of the group into genera is not yet necessary. With regard to the latter point, it should be remembered that the object of the descriptive natural sciences consists by no means in the mere registering of natural bodies, but involves the unveiling of those differences, subordinate one to another, by which nature has changed the original simple type into so many various forms. Having once correctly recognized such distinct degrees of modification, and having made out the characteristics of these modifications, we then consider them as genera, or speaking generally, as groups to which we give special names, in order to remind us of the peculiarity in the modification of the fundamental type. For this and for no other reason is it that we give names to the groups, intending simply to facilitate the interchange of ideas and experiences, just as the use of coin facilitates commercial intercourse. Quenstedt's predecessors knew this quite as well as his successors have appreciated it, and made it their object to establish well-founded genera. Boeck only attempted to indicate these (in Keilhaus 'Gaea Norwegica,' 1838), reserving for himself the particular description in a 'Monography of the Trilobites,' which has long been announced, but which has not yet made its appearance. Emmerich in this, however, has anticipated him, succeeding Quenstedt as assistant at the Mineralogical Museum at Berlin, and likewise following in the footsteps of the latter naturalist, and choosing the Trilobites as the particular object of his studies. In his carefully executed work (Diss. Inaug. Berol. 1839) the general part is certainly not much enriched by new facts or views, but the special part is written with a careful investigation of the manifold synonyms, and built on the gene-

* I believe that I was the occasion of this statement. During a visit to the Mineralogical Museum at Berlin, at which M. Quenstedt was then assistant, I explained to him my views respecting the Trilobites, their structure and their affinities, and laid particular stress on the importance of the numerical proportions. The statement alluded to was published a few months subsequent to that conversation.

rally correct basis which Quenstedt exhibits in this respect. The group of the large-eyed species, furnished with eleven articulations, which was first recognized by the latter, was named *Phacops* by Emmerich, and appears as a genus, besides eight others, of which the second (*Odontopleura*) is also new and well-founded, but cannot be satisfactorily recognized by the very defective illustrative figure. Emmerich has also followed his predecessor in this respect, that he extends the identity of *Homalonotus* and *Trimerus*, first announced by Murchison (and to which Bronn subsequently—1840—also added *Dipleura*), to *Calymene*, considering the group merely as a subdivision of it. He unquestionably, however, goes too far in this respect, especially when he separates from it *Dipleura*, which of all the three forms is most nearly related to *Calymene*.

Next to this work there follows a brief but sound and valuable account of the Russian Trilobites by L. v. Buch (1840), containing a correct view of all essential characters, namely, a comparative study of the relative proportions of the head, trunk, and tail, and the relation of the separate parts to the whole. "By proceeding in this manner only can we expect real natural historical classifications, such as rise above the poor purpose of serving as convenient indices to collections and catalogues." This is perfectly true, but the contemporary works of the Count v. Münster (1840 and 1842) unfortunately do not soar beyond that purpose, for they scarcely furnish a single perfect description of the many new species exhibited, and only indicate obscurely in the illustrative plates the real forms to which they probably belong.

The paradoxical forms which Goldfuss has published (1841) offer, both in perfection of representation and description, a magnificent contrast to the last work, and cannot be too strongly recommended as a pattern to those who henceforth wish to describe Trilobites from fragmentary specimens. The newest work on this subject, one recently published by Milne Edwards, in the third volume of his 'Histoire Naturelle des Crustacés,' tom iii, 1841, embraces indeed everything connected with the subject, but, on the other hand, is by no means worthy of the name which this distinguished French naturalist has procured for himself by many excellent works. The arrangement of the *Trilobites* between *Isopodes* and *Phyllopodes*, which the author follows, does homage to all the different views hitherto proposed on the subject, and therefore does not bring the matter to a decision; but in this case the truth lies by no means, as it often does in other cases, in the middle. Among the assumed twelve genera, several, as *Pleuracanthus*, *Peltura*, and *Otarion*, are founded on misunderstood fragments, and the same may be said of many species which the author copies from his predecessors without any further investigation. It is to be regretted that so profound a zoologist, who may justly be considered by the many as a distinguished authority, has paid so little attention to this part of his otherwise very meritorious volume, and has thus furnished a work which can only be considered valuable as a mere compilation. It certainly has not advanced us one step in our knowledge of the structure of these animals.

THE ORGANIZATION OF TRILOBITES.

CHAPTER I.

ON THE VISIBLE STRUCTURE OF THE BODY OF THE TRILOBITES.

SECTION I.

The body of all Trilobites consists of three distinct divisions, which have received the denominations of *caput*, *thorax*, and *abdomen*. They may be recognized as ARTICULATA by this characteristic alone. The first two divisions include many associated parts, constituting the *cephalothorax*; but these remain separated in the Trilobites, and this circumstance not only greatly facilitates the special examination of their body, but also affords convincing information respecting their affinity to existing species. Postponing the investigation of their affinity to the next chapter, we shall now consider the remains of the Trilobites, as they are presented for our examination.

SECTION II.

The remains of the Trilobites are limited to the shell and its impressions, and no softer part of their body has, or indeed could be preserved. Hence it appears to me certain that all those parts which possess the hardness of the shell, or at least were clothed by any substance as hard, must exist in the impressions of the Trilobites; and that, on the other hand, those parts which probably existed, but which are wanting in these impressions, did not possess the firmness of the shell, and are absent on that account. If, therefore, as is the case, we no longer perceive the entire abdominal surface of the Trilobite body with all its attached organs, we must infer that they had a much softer membraneous covering and consistency, but we can by no means infer that those parts did not exist. This view of the subject is rendered more probable, when we observe the same quality of the abdominal surface and its organs in still existing organic bodies which are similar to the Trilobites: indeed, a more particular comparison of the existing Trilobite remains with the shells of such living animals raises our assumption to a positive certainty, since we also recognize the greatest similarity in the latter. An accurate knowledge of the shell of the Trilobites is therefore, the first and most important requirement for the observer.

SECTION III.

My observations on this subject must be preceded by the explanation, that the real shell has by no means been preserved in all the Trilobites, but that a great part of their remains consists merely of impressions from the shell. This is the case in all the Trilobites of the grauwacke and of the clayslate, therefore particularly in the *Olenidæ*: undoubted remains of the shell itself are first found in the specimens from the alum slate, and the same is more or less perfectly preserved in most of the individuals inclosed in the transition limestone.* In individuals from this rock, especially in such as are found as loose stones in many localities of Northern Germany, and which are already perfectly freed from the limestone that formerly surrounded them, we see most distinctly that the shell consisted of two layers, of which the external one extended itself over the lower, thicker, darker layer as a very thin, and generally clear coloured, coat. This fine coat is closely covered with small uneven tubercles, or is granulated on its whole external surface, and has therefore quite the appearance of the horny shell of our river crawfish, especially at the claws. These granulations were so slight over most parts of the body, that they left no trace at all in the second or lower layer of the shell; but their presence in the more elevated portions, as, for instance, in the arched anterior portion of the head, and on the rings of the body, betrays itself, even when the upper membrane is wanting, by light but larger tubercles, which cover these spots. They attain their greatest development in the *Calymene variolaris*, which derives its name from them, but they are likewise not wanting in the Dudley Trilobites (*Calymene Blumenbachii*). It is only in these, and in the smaller specimens (var. *pulchella*), that I have hitherto been able to observe the external layer with its granulations in a well-preserved state; the upper layer is almost always wanting in the granulated species of *Phacops*: the general granulation, therefore, can only be inferred from the existence of those larger granulations of the lower layer of the shell. The granulated surface, however, seems to have been a general quality of the group in the two genera *Calymene* and *Phacops*, and seems to belong to all their species. Most published figures of *Phacops* confirm this opinion; the granulation in the genus *Calymene* has generally been overlooked, because it is here much finer and slighter, and because it is usually only recognized on the upper membrane itself. If, however, the second layer of the shell has likewise been cast off, and if the impression of the interior of the shell of the Trilobite only is existing, those indistinct coarser traces of granulation are, as a matter of course, also wanting, and the surface appears to be smooth. This is not only veryfrequently the case with regard to *Calymene Blumenbachii*, but also very often with *Phacops latifrons*, and with regard to the latter has given rise to the enumeration of several species (*C. latifrons*, and *C. Schlotheimii*, Bronn). *P. protuberans*, and all the species of this genus which are described as smooth, seem to originate from those individuals the membranes of which have been cast off.

* These remarks were intended, no doubt, by the author, to refer chiefly to the distribution of Trilobites in the rocks in his own neighbourhood. The actual shell of these animals is found frequently in the Silurian limestones in England, and sometimes in the Caradoc sandstone, the oldest rock in which they appear. The shell is found also in the Devonian and carboniferous limestones.—Eng. Ed.

SECTION IV.

The upper membrane just described seems only to be a peculiarity occurring in the genera mentioned, and of some others (*Brontius, Odontopleura, Homalonotus*), but wanting in most of the Trilobites. Not even the slightest trace of a more delicate layer, capable of being thrown off, can ever be discovered on the surface of the shell of perfectly well-preserved remains of the genera *Asaphus* and *Illænus*, indicating a different quality of the horny covering of these genera. In individuals whose external surface is in some places not at all injured, I perceive, on the other hand, fine deeply cut lines, which run pretty much in the same manner as the furrows in the palm of the human hand, but are situated more remote from one another, and have fine punctured dots between them. I observed this character of the surface-membrane in *Calymene* and *Phacops*, but most distinctly in *Asaphus expansus*, var. *cornigerus*, upon the arched anterior portion of the head, and at the most elevated parts of the rings of the body, and often exactly at those points where the granulation is most perfect; on the other hand, I noticed those fine points in greater number and in a closer position on the lateral portions of the cephalic shield, on the lateral lobes of the rings of the body, and on the caudal shield, but in those places they are only single, coarse, rather elevated diagonal lines, which, however, are distributed in a tolerably symmetrical manner. This formation likewise meets with its analogue in living Crustacea, and may be found in the thorax of the lobster, particularly as regards the punctures.

These granulations and punctures, however, only exist on that surface of the shell which is at the superior side of the animal, for the inferior surface, as far it has been preserved, has a different structure. It was likewise covered by a peculiar, but always thinner, horny membrane, which, however, gradually became more delicate the nearer it approached the middle, being everywhere separated from the upper side of the shield by a layer of muscle, and itself consisting of a softer structure. These statements may be verified by observations; and, as one reason in support of them, I may state that we always find in the remains of Trilobites, in which both layers of the shell are existing, that there is a layer of rock between them, which indicates their distance from one another. As another reason, we may state that we observe at once the thickness of the petrified shell by such layer of stone, and perceive that the lower layer is thinner than the upper. For the better understanding of these proportions, I beg to refer my readers to the illustration of the large *Asaphus* shield, which I have given in Plate V, Fig. 4. This shield is still covered on its left side by its old petrified shell, furnished with its natural surface, and therefore only exhibits a tolerably well-defined system of parallel striæ at that part of the anterior margin which was overlapped by the lateral lobes of the last thoracic ring. A sharp broken edge, which at first runs along the whole length of the middle of the abdomen, and then turns towards the left, indicates the limit of the broken shell. That which is still visible towards the right is only the impression of the shell on that part of the stone which penetrated into the shield of the abdomen. From this part, however, a considerable piece is broken off at the posterior margin, and there is not only visible a part of the lower shell, but also its impression into the stone situate beneath it, at those points where the shell itself is wanting. This accidental quality of the shield proves distinctly that the lower surface of the

shell is furnished with fine parallel lines, as in the covered part of the upper surface at the anterior margin; that it consists of a horny membrane, thinner than the latter; and that the distance of the two membranes from each other was much greater in an angle of the lower layer than at the other parts of the whole shield, greater indeed even than at the end of the real abdomen, the lancet-formed point of which—at least in this case—seems to have been flat. For there seems to me no reason for supposing that this part was flattened by external force, and was originally arched downwards, since the parallel angle of the lower side is perfectly preserved, and not flattened, which certainly would have been the case if the whole shield had suffered considerable pressure.

The lateral lobes of the joints of the body and the whole cephalic shield are formed also like this shield of the abdomen. Thus we may most distinctly convince ourselves, from many fragmentary specimens, that the entire lower surface of the shell of the head was covered in the neighbourhood of the anterior margin with such deeply cut parallel lines, giving that surface the appearance of a regular striation, the furrows of which run parallel with the circumference. The interior as well as the exterior surface of the lateral lobes is formed in a somewhat similar manner, though not entirely so, as far as the latter is covered by the preceding lobe. On this lobe, however, the lines run lengthwise, are not so deep, are frequently furcated, and are in general not so regular as at the cephalic and caudal shield. I have nowhere been able to perceive the dots between these lines of the lower surface, which are situated between them at the upper surface, and which even occur at many places by themselves, without the lines; they are here, as they are generally, wanting as the granulations at the lower surface of the species of *Calymene* and *Phacops*, in which, however, the cross striæ described are as generally found as they are in *Asaphus* and *Illænus*. We have not, however, so many opportunities of observing them, since most specimens of these genera, and indeed always the most beautiful ones, are rolled up, so that we are unable to observe any of the parts of the lower surface.

This is all that I have been able to ascertain with certainty as to the nature of the shell of the Trilobites. I suppose the same structure to be existing in the *Olenides* as in *Asaphus*, at least I have been able to convince myself of a similar striation of the lower surface. Genker has also observed the same, and indicated it in his figures, for instance, in Table V, Fig. c d.

SECTION V.

Proceeding to the subject of the divisions of the body, and commencing with the consideration of the head as the first, we shall soon observe that this part is encased in a great parabolical semicircular lunate shield (*scutum capitis*, cephalic shield), in which the head itself only occupies the central, and, therefore, the more highly arched part. This central part, the head itself, which I shall henceforth call head-tubercle (*Kopfbuckel—glabella*, according to Dalman), is very distinctly characterized by a furrow round it of greater or lesser depth, is always rather longer than broad, generally broader and thicker at the anterior part, and is there also more highly arched and more strongly projecting. In many instances impressions exhibit themselves on the whole elevation, which proceed from the furrow surrounding it, and which, more or less, penetrate into the head-tubercle, some-

times even (as in *Paradoxides* and *Olenus*) becoming complete cross furrows.* There are at the utmost three such furrows at each side, separating lobes from the lateral margin of the head, which are partly even, partly uneven, and in the latter case form the broader lobes either on the posterior part (*Calymene*), or on the anterior part (*Phacops*). In other cases they are entirely wanting (*Illænus*), or are only indicated as slight depressions of the margin of the head (*Asaphus*). Next to the central head-tubercle is seen the cephalic shield, which, however, generally is not quite flat, but likewise slightly arched, so that it declines more or less towards the circumference, thereby forming a cavity beneath it. Of its two margins the anterior is always more strongly curved than the posterior, the former frequently representing a very pointed parabola or hyperbola (*Isoteles*), whilst the latter only exhibits a circular arch. The latter becomes deeper in proportion to the greater or lesser projection of the frequently long pointed lateral angles. The margin of this cephalic shield is either extended flatly (*Asaphus, Isoteles*), or has a distinctly protuberant margin; in the latter case either having an acute angle (*Calymene*) or being rounded off (*Phacops*). The central portion of the posterior margin, at the part where it covers the first ring of the body, usually projects in a thickened, swollen, and even ring-like form (*Asaphus*); the furrow-deposit, however, which I shall call neck-collar (*Gelenkwulst, sulcus verticalis* of Dalman), also usually disappears towards both sides so rapidly, that it scarcely extends beyond the middle of the lateral lobes. In other numerous cases the collar extends quite as prominently in the middle of the posterior margin, but is distinctly separated from the central part, as far as the lateral angles, then passes round, surrounding the latter, and is continued along the entire anterior margin, frequently appearing there still higher, stronger, and more distinct than at the posterior margin (*Calymene, Phacops*). All these differences are pretty constant characteristics of genera or groups, and therefore demand an attentive observation; this particularly has reference to the lateral impressions of the head-tubercles, since these are probably not mere ornaments, but may perhaps have reference to the organization of the mouth. We usually, indeed, find swellings and protuberances on those localities of the shell of the Articulata where strong muscles are attached internally, and the elevations situated between the transverse impressions may, therefore, probably originate from such attachments of the tracheal muscles; so that from their number we might infer the number of gills. It certainly seems opposed to this conjecture that the organization of the internal part of the mouth in the case of other natural groups of Articulata is generally uniform, while in the Trilobites the impressions on the head are generally very different. The force of this objection, however, may be diminished by assuming that the forms in which we find defective impressions were characterised either by a greater thickness of the shell, or by a slighter development of the muscles, so that the traces of the impressions of the muscles were rendered less distinct, or were entirely effaced. And, in fact, the genera in which such impressions are wanting (*Illænus, Asaphus*, and some species of *Phacops*) seem to possess a

* If we place confidence in this characteristic of many perfectly preserved *Olenoides*, namely, that the cross furrows of the head-tubercle are complete, and if we may consider it as a general family characteristic, several forms would belong to them which have hitherto only been observed in imperfect specimens. According to this, we should particularly have to enumerate *Trilobites Sternbergii* (Table III, Fig. 7), which, in point of the cephalic structure, is most nearly related to *Olenus scarabæoides*, and *Triarthrus Beeki* as both belonging to the *Olenoides*.

very powerful and thick shell, whilst in the *Olenoides*, which always present impressions, the shell was decidedly thinner, and consequently became entirely lost. The few existing positive facts, however, do not permit us to determine this point with certainty, and we must, therefore, content ourselves with having pointed out the possibility of one or the other mode of organization.

SECTION VI.

The number, position, and structure of the eyes can be ascertained with much more certainty, and are therefore comparatively well known. There are, however, still many deficiencies in the knowledge existing on these points, which is the more surprising since we are enabled to make a perfect representation of them from actual observation.

In all those Trilobites the eyes of which can be distinctly recognized, we see them in the shape of more or less considerable prominences at the sides of the head, nearly on the centre of the lateral portion of the shield, projecting from the latter. They are here seen as portions of a spherical or parabolic surface, under a semicircular projection (the cover of the eye, or of the horny covering of the head), which projection is formed by the sutura temporalis, (of which a description will be found subsequently,) and in reality they fill out a chasm that is situated at this locality between the two opposite margins of the suture. The eyes project in the shape of a half-cone, flattened on the upper part, if this vacuity is large; if small, it forms a lunate protuberance, which is so slight in some species that it scarcely rises above the contiguous surface of the head. Such Trilobites have been considered as blind; and with regard to *Olenus*, which genus possesses the structure described, it is given as a generic character. The eyes of the *Illenus* are in the shape of a moderately arched, lunate swelling; in *Asaphus*, *Calymene*, and *Phacops*, they appear as more highly elevated tubercles or hemispheres. Whilst the external surface of the eyes in the other genera is perfectly smooth, and even more so than the neighbouring horny covering, there appear in *Phacops*, instead of these, small hemispherical elevations distributed over the entire surface in regular order, the small interstices shaping themselves into protuberantly swollen inclosures of the hemispheres. Owing to this, the eyes of the Trilobites are usually represented as being formed on two different types, assigning to the former a smooth, to the latter a facetted cornea. This view, which is entertained by all former observers, I must consider as decidedly incorrect: first, because there is not a single existing family of Articulata in which the eyes are formed according to two different types; and, secondly, because the character of the facettes in *Phacops* is quite different from the mode of formation predominating among the Articulata with a facetted cornea. I am rather of opinion that all Trilobites possessed compound eyes with a smooth cornea, and that the latter has merely been lost in those genera in which facettes are perceived. In addition to the two reasons mentioned, I am further justified in this assumption by the fact that the cornea of most of the Trilobites is really smooth, and that the structure of the eyes of those species, to which a facetted cornea is attributed, is in every respect such as it would be if their eyes possessed a simple, smooth cornea, which was subsequently lost. This, therefore, seems to be the proper place to explain more particularly the structure of the compound eyes with a simple, smooth cornea.

SECTION VII.

Eight years have already elapsed since I particularly described the type of this form of the eye (to which Müller* first directed attention), in its most important living representative, the *Branchipus stagnalis*, and I then showed that the eye of this animal consists of four successive layers of different kinds. The external layer is a smooth, homogeneous, transparent cornea. Beneath it lies a facetted membrane, which, seated in a clear substance, contains rather darker, firmer, circular, apertures, of equal size, and regularly distributed in such a manner that every ring is surrounded by six others, at equal distances from each other. The third layer of the eye consists of egg-shaped, transparent, very hard lenses, each of which is situated behind one of the little window-like apertures described, resting upon the surface of the latter with its flatter extremity, and raising this a little with that convex surface. The fourth layer consists of an oblong, club-shaped, crystalline body, which encircles with its upper thicker end the more pointed end of the egg-shaped lens, and is surrounded by a delicate membrane. A continuation of this membrane also overspreads the lens, and attaches itself to the thickened margin of the little aperture before each lens. Behind the crystalline body there then follows the dark pigment as the principal mass of the whole eye, through which the fibres of the optic nerves extend themselves to the respective ocelli, resting on the basis of the crystalline bodies, as their sheaths pass into the sheaths of the crystalline body, and the lenses, and through those sheaths likewise attach themselves to the facetted second membrane.† This representation of the eye,‡ which is perfectly applicable to the Trilobites with a smooth cornea, shows us that the loss of the external smooth cornea immediately occasions the projection of a facetted cornea,§ and we therefore only need assume with respect to *Phacops* that their cornea must have been more destructible than that of the other Trilobites, in order to explain their facetted character. Sufficient reasons are also in this respect furnished to us by the proportions of organization in existing genera. The study of all those Crustacea, for instance, that are furnished with a smooth cornea, and they are only found in Articulata of that description, proves to us the important fact, that the number of the separate ocelli does not at all depend on the size of the whole eye, since they merely become more minute as the eye diminishes, their absolute number in that case sometimes actually becoming greater. The cornea becomes thinner in proportion to the increased size of the eye, and thicker as the eye is smaller; so that very large eyes with a smooth cornea possess a thin cornea,‖ very small ones, on the other hand, a thicker and more compact cornea. Now *Phacops*

* Müller's Archiv for 1835, pp. 529, 613.

† *Vide* Table VI, Fig. 4, and its explanation.

‡ *Vide* Quenstedt in Wiegmann's Archiv für Nat. Gesch., series 1837, i, 340; where the structure of the eye of the Trilobites with a smooth horny membrane is correctly recognized and described.

§ In Joh. Müller's description, which we have before alluded to, the facetted membrane and glassy substance is not mentioned. We need not, however, infer from this that they are wanting in some eyes; they have only escaped the attention of the observer at this first investigation, and are certainly met with in all the Articulata with the described form of eyes.

‖ Compare in these respects, for instance, the genera *Branchipus* and *Apus*, or *Polyphemus* and *Daphnia*.

has, relatively speaking, the largest eyes among the Trilobites, consequently also the largest lenses and the thinnest cornea; a fact which is decidedly established, and sufficiently explains the absence of a smooth appearance in the eyes of this genus.* The truth of this view is, however, still further supported by the circumstance that the facettes in all the Crustacea, and in most of the Articulata with a facetted cornea, are perfectly contiguous, leave no open interstices, and individually are much less convex than in *Phacops*. The eye of the latter genus, if it possessed a facetted cornea, could only be compared with the eyes of some nocturnal insects, for instance, of the *Reduvies*, or of some of the parasites, such as the *Rhiphidoptera*, in which the facettes are larger, more strongly arched, and situated more remotely from each other, or it might be explained as an aggregate of simple eyes; against which conjecture, however, there would always be the fact of their peculiar circumscribed form. Aggregates of simple eyes, as they occur in *Myriopods*, and in some of the *Isopods*, consist however always of a smaller number of ocelli, whilst the number found in *Phacops* is very considerable.† Thus I believe I have proved the correctness of my assertion, that this genus, in common with all other Trilobites, possessed a smooth cornea. Before concluding this part of the subject I might, however, refer to the frequent actual deficiency of the cornea and lenses in *Calymene Blumenbachii*, and quote the absence of the latter, which naturally arose from the small size, as an additional argument in favour of my view. These parts of the eye were, indeed, so small in this instance, and their coats so tender, that they could not have been petrified after the loss of the protective horny cornea membrane.

SECTION VIII.

We shall now return to the already mentioned *linea facialis*, or *sutura temporalis*, and trace the principal variations of these lines. There can certainly be no doubt that the possession of a temporal suture is a common character of all Trilobites; it exists equally in *Paradoxides* and *Olenus*. It is generally first recognized at the anterior margin of the common cephalic shield, at a moderate distance from its centre, so that both lines remain at a rather greater distance from each other than the transverse diameter of the cephalic protuberance at its broadest part. But in *Ogygia*, *Phacops*, *Homalonotus*, and *Isaphus*, the temporal sutures extend themselves at the anterior margin to the extreme point of the cephalic shield, and here unite, forming an arch or angle. In the other genera they are curved on the lower side, round the anterior margin of the head, and terminate in the margin which separates the cephalic shield from the mouth. Converging a little towards the posterior part, they now approach from the margin to the protuberance, as far as the region where the eyes are situate, here they describe the outward curved lobe over the eye (operculum oculi) already alluded to, and again extend behind it rather more towards the outer part to reach the margin of the cephalic shield at a second point.

* Since the publication of the German edition, I have observed in the eyes of *Phacops mucronatus*, from Bohemia, the globular spots hollowed out like a funnel, all regularly in the same manner; a form impossible, I think, if the spots were cornea.

† I counted 162 hemispheres of lenses in each eye of the *Phacops arachnoides*; of *Phacops mucronatus*, on the other hand, 209; of *Phacops latifrons*, only 96-100.

The part where this takes place is very differently situated, and is, in some cases, at the posterior part of the margin of the head, but in others, at the exterior part. Each genus has a certain point at which this takes place, and it is different in each. *Paradoxides* stands in this respect at one end of the series and *Phacops* at the other. The point of termination in *Paradoxides* is, for instance, situated much nearer to the raised margin of articulation or collar of the cephalic shield than to the lateral margin, and both extremities of the suture are only just as far removed from each other as the eyes are. The latter proportion exists also in *Illænus*, but owing to the great distances of the eyes from each other, the distance of the ends of the sutures from the central line is much greater than their distance from the lateral margin. In both these genera, however, the sutures posteriorly run parallel in the principal direction; but they diverge in all others. This divergency is slightest in the species of *Oggygia* and *Asaphus* and in *Paradoxides gibbosus*, and *Calymene concinna*, which do not however belong to the genera the names of which they bear, and it is so great, that it extends beyond the centre of each lateral lobe of the posterior margin of the head; in *Calymene Blumenbachii*, and in the other real species of the same genus, it increases to an immediate termination into the angle of the cephalic shield itself,* and in *Phacops* even passes over to the external margin of the cephalic shield, as Dalman has already illustrated this in *Ph. sclerops*, his *Calymene sclerops* (Tab. III, Fig. 1, d). The two ends of the sutures in this case nearly describe single straight lines along their principal direction, and these lines are at right angles with the longitudinal dimension of the body, so that they are therefore removed by about 90° from the direction observed in *Paradoxides* and *Illænus*, as well as from the other extreme. It is evident that so constant and regular a course must be particularly calculated to afford safe characteristics of genera. Besides this temporal suture, which is common to all Trilobites, I have further observed a second real suture in the crust of the head, which has been overlooked by most authors.† It is only found in the genera *Calymene* and *Illænus*, immediately beneath the upper angle of the anterior rim, on that side of the latter which is turned downwards, and connects the two parts of the temporal suture, which in their termination incline somewhat inwards. It is, however, only to be detected in very well preserved specimens, but in such it can be seen quite distinctly, and in *Calymene* it not only occurs in the granulated upper membrane already described, but it also exists in the second layer of the crust lying beneath the former. In all other genera, I could not discover any trace of this second suture, or *sutura marginalis*, and must therefore assume that it does not exist in these genera.‡ Indeed I find that we meet with three quite different types in the composition of the cephalic crust among the Trilobites, the principal differences of which consist in the circumstance that this entire shell, as far as we know it, may consist of two, three, or four pieces.

* The edges of the head are always short if the suture divides them, but often elongated into angular processes if the suture goes to the basal or external margin. These processes are only productions of the crust, and are solid, without any hollow, so that they could not exist if the fossil were a crust, but only if the crust itself of the animal be petrified. Hence it is that individuals of the same species, as *Phacops sclerops*, occur some with long horny head-processes, and others without any.

† It has been pointed out in Buckland's Fig. 3, Table XLVI, and Murchison's Fig. 7, Table VII.

‡ M. Emmerich, in his 'Dissertatio de Trilobitis,' p. 8, (Berolis, 1839, 8vo,) also speaks of two sutures at the cephalic shield, but describes the temporal suture only more accurately; the second (quæ partem inferiorem a superiore separat) he merely refers to in these words. I have nowhere seen it at the whole circumference of the cephalic shield.

The temporal sutures in the first case, by no means pass over to the lower side of the cephalic shield, but continue at the anterior margin of it, and there meet together, so that both are only the different directions of one suture going towards the left and the right. This formation I observed in *Oggia*, *Phacops*, *Asaphus expansus*, Wahl., and in all flat-headed species of this genus, as far as I have been able to investigate them. This transition takes place in the shape of an arch terminating near to the anterior margin in *Asaphus expansus*, *A. læviceps*, and *A.* (*Nileus*) *armadillo*, as also in *Oggia* and *Phacops;* it takes place, however, in *A. ramiceps*, *A. angustifrons*, and *A. extenuatus*, in a sharp, more or less pointed, angle. I could never recognize a suture proceeding from this point, which had divided the lower surface of the shell, with any degree of certainty; Pander, however, has found such, and considered it as the line of separation of his side branchiæ (*vide* Table IV, B, of his work). The entire *cephalic* shield of this pointed headed *Asaphus* likewise therefore only consists of three pieces, an upper internal one, which covers the cephalic protuberance, and which I term *central shield* (*scutum centrale*), and two upper external ones, which at the same time pass over to and form the lower side, as far as we are acquainted with it. I call them *margin shield* (*scuta marginalia*), or *temporal shields* (*scuta temporalia*). In the second case the two temporal sutures extend themselves over the anterior margin of the head, and reach, separately, that lower margin of the cephalic shield which incloses the region of the mouth, and which I shall subsequently describe, separating it from the cephalic shield. The anterior end of the central shield in this case, therefore, also passes over to the lower side, and thus we have three shields of the head-crust, a simple central shield, and two margin shields. The *Olenoides* belong to this group. The central shield in these only occupies the central part of both margins, and the entire lateral portions complete the marginal shields. The two temporal sutures, in the third case, also terminate quite separately, reach exactly the angle of the head-crust at the posterior part, but are connected anteriorly beneath the protuberant margin of this crust by a transverse suture, which here separates a piece of the lower surface of the shell placed anteriorly to the region of the mouth, so that four pieces are thus formed, viz. a central shield, two marginal shields, and a shield situated in front of the mouth, which I term *scutum rostrale*, and the suture which separates it I also term *sutura rostralis* Such a structure may be met with in *Calymene* and *Illænus*.*

Such is the account I have to offer concerning these sutures of the head-crust; I have only further to observe, that similar unions of the pieces of the crust, by means of sutures, cannot be traced in any of the existing Crustacea, but are only found in true insects of the present world; they constitute, therefore, a most remarkable and important peculiarity of the Trilobites. We shall see subsequently that they do not occur again at any of the other segments or shields of the shell of the Trilobites. No satisfactory conjecture as to their purpose can indeed be hazarded without an accurate observation of living animals. Pander's opinion (p. 117), "that the connexion of the parts is perfectly dissolved by this suture," and that in the living state of the animal it had served for the purpose of removing the lateral shields from the central, and thus permitting a changeable distance of both from one another, at the option of the animal, can scarcely be founded on fact, for at the present day we by no means find

* Professor Löven observed in the genus *Trinucleus* or *Cryptolithus* a new and very different type marked by the course of the sutures, which I shall describe in giving the character of the genus.

so great a mobility in those Articulata, whose shell pieces are connected by sutures; on the contrary, the mobility of the plates upon one another is always very slight, and a considerable distance of the margins of the suture from one another is impossible, if it were only because a soft membrane arises from the internal margin of the sutures, connecting intimately both the suture margins. Owing to this, the elements of the skeleton of the highest Articulata can at the utmost be only bent towards each other, never being separated from one another to any considerable extent. The facial suture of the Trilobites probably likewise admitted of such an easy bending of the lateral shields towards the central shield, and might be intended for the purpose of arching the space beneath the cephalic shield somewhat more during the contraction, so that the requisite height might be gained for the feet, which were then hidden beneath the cephalic and caudal shields. Indeed the intimate union of the lateral lobes of the segment of the trunk in one section at the posterior angle of the *scuta temporalia* testifies that the object was to conceal all the lower parts as much as possible beneath the head-crust during the rolling up of the Trilobites.* Such a section is found at the lower side of the angle alluded to, immediately behind the external margin; it is particularly distinct in the genera *Asaphus* and *Illaenus*, visibly sharpens the margin, which before that point is thick, broad, and rounded off, and thereby causes a cavity in the margin itself, running parallel with the acute angle, the cavity being intended for the reception of the lower end of the last lateral lobe, situated before the caudal shield, when the Trilobite was rolled up. The axis, around which the animal doubles itself, is situated very near to the locality where the two furrows, which run parallel with the lateral and posterior margin of the *scuta temporalia*, meet together before the posterior angle, and the lowest ends of the lateral lobes of the joints of the trunk also usually conceal themselves to that extent beneath the cephalic shield. The excavation behind the margin before described serves, therefore, for their reception, and indicates that a Trilobite possessing it had the power of doubling itself together. On the other hand, however, it will not do very well to infer from the absence of the section, that such a Trilobite could not have rolled itself up. I certainly have always looked in vain for it in all the Olenoides, nor have I ever perceived any traces of the capability of doubling themselves in these Trilobites; but I could quite as little discover that section in *Phacops* and *Calymene*.

SECTION IX.

We have now still to investigate those remains of the existing parts of the cephalic crust, which have been observed on its lower surface behind the margin, and evidently in front of the mouth. The first who observed this region of the head in *Olenus Tessini*, Dalm., was Wahlenberg; he took it, however, for the impression of the upper side of another species, and described it as *Entomostracites bucephalus* (p. 37, 10, Table I, Fig. 6, of his work). Subsequent to him, the same region was observed and represented by Stokes in *Isotelus gigas* (his *Asaph. platycephalus*), and by Eichwaldt in *Asaphus expansus*, Wahl. (his *Cryptonymus Panderi*), but they were not correctly observed by them. The same may be said of Pander,

* Table VI. Fig. 8, *f f*.

whose representation is certainly more particular, but without any correct interpretation of what these parts really are.* Sars was the first who recognized them for what they are, namely, for the lower protuberance of the head before the mouth, and described them as such in the genera *Illænus* and *Asaphus* ('Isis,' 1835, p. 340, Table IX). I myself have only hitherto observed this region perfectly in *Phacops* and *Paradoxides*; in *Asaphus* and *Illænus*, however, I have discovered them so distinctly, that I cannot doubt their existence, and the correctness of those former representations. The great similarity in the figures of the four authors, who, however, were not acquainted with the works of their predecessors, also speaks in favour of this opinion. The following is the structure observed.

A moderately arched protuberance, which in size and circumference corresponds pretty nearly with the most anterior portion of the head on the upper side, exhibits itself immediately behind the thickened anterior margin of the cephalic shield, that part which Pander terms lateral gill. It was intimately connected with the anterior margin of the head, and has certainly not been moveable at pleasure, as Pander supposes, in consequence of its isolated position in some individuals. (*Vide* Table IV, B, Figs. 3, 4, of his work.) From the anterior part it extends itself with a pair of lateral lobes, which are more or less distinctly separated from the central lobe, along the margin indicated, towards the external part, and there terminates in a long, more pointed, less arched projection. Towards the posterior part in *Paradoxides* there is a rather protuberant margin, curved outwards, and before it a considerable oblique excavation. This margin in *Asaphus* and *Illænus*, on the other hand, is deeply notched and strongly double lobed. In all three are exhibited on the whole surface the same indented concentric lines, which cover the lower surface of all parts of the shell. Sars certainly represented such lines only on the lateral lobes, but I have found them everywhere on the whole surface in *P. bohemicus* (*Ent. bucephalus*, Wahl.), but certainly slighter in the centre, and therefore I suppose that Sars must have overlooked them. I have represented this region of *P. bohemicus* on Table I, Fig. 7, and have availed myself of Sars' figures of *Asaphus* in my drawing, Table VI, Fig. 8.

There can now scarcely be a doubt that this region is the ordinary enlargement before the mouth, which we perceive in the *Phyllopodes*, and which is usually called *hypostoma*. This certainly testifies as decidedly in favour of the affinity of the two groups, as it negatives the affinity with the *Isopodes*. But of this hereafter.

SECTION X.

The *thorax* or *body* of the Trilobites, to the description of which we now proceed, consists of a number of homogeneous rings, of which every one likewise possesses a horny crust. The latter has, as on the cephalic and caudal shield, lateral freely projecting lobes (*pleuræ*) at each ring, which are readily distinguished by their flattened and generally incurved form, from the uniformly arched semi-cylindrical body. These lateral

* Pander supposed that these, as well as the lateral margins of the head that are turned over, were gills; and terms the latter *lateral gills*, the central swelling behind the anterior margin *central* or *lower gill*, and even believes that there were respiratory organs in the swelling before the mouth. (*Vide* pp. 124 and 128 of his work.)

lobes consisted (exactly as in the already described flattened extensions of the cephalic and caudal shield) of two layers, between which there was a thin layer of the substance of the body, and these were, on the external, open, upper surface, partly smooth, partly granulated; but on the lower hidden surface furnished with parallel striæ. This is distinctly seen in the fragments of *Asaphus* and *Illænus*, in which both coverings of the lateral lobes are generally preserved, showing that the intermediate layer at the upper and internal parts of the lateral lobes was thicker than at the lower part, (which is curved forwards,) where each lobe terminated in an acute angle towards the external and upper part. On the other hand, it formed a broader rounded facing. If I appreciate these impressions correctly, I should say that the internal horizontal part of each lateral lobe must have been in immediate connexion with its neighbour, and that this whole region of the body has participated in the protection of the fleshy muscular layer, situated beneath the arched central part, or may even have been partly the support of this muscular portion. This is probable, since in all the specimens, even those that are rolled up, these regions of the lateral lobes are not projected one above another, but are at the usual distance from each other; and I think I can perceive a kind of articulation in the anterior angle of each posterior ring, where the external part of the lateral lobes bends downwards. Such an articulation certainly exists at the place where the central arched part of each ring meets the lateral lobes, not, however, between this part and its lateral lobe, but between the central arched body rings themselves. At this spot, indeed, may be observed a strong hemispherical articulated head, immediately before the open posterior margin of the ring at its lower surface; and this head fits into an articular cavity, formed to fit it in the succeeding ring. The latter exists at the anterior margin of the caudal shield, and is distinctly represented in Table V, Fig. 4. The first pair of articular processes occurs, however, at the posterior margin of the cephalic shield, and thus each segment has a pair of articular cavities on its upper side anteriorly, at the junction of all the rings with the preceding covered margin; and on the other hand, at its lower free side, which partially projects over the succeeding ring, it has a pair of hemispherical articular processes. These and the cavities may be very distinctly recognized in the larger specimens of the species of *Pharops*, whose horny coat has been lost; the fractured articular prominences being usually still found in the articular cavities beneath them. There can also be no doubt, from the analogy of living Articulata, that besides this a soft articular membrane connected the margins of the rings, situated opposite to each other; but in all other respects, each separate ring was complete in itself, its lateral lobes being immediate continuations of the central arched principal portion, and nowhere connected with the latter by means of sutures. It is true indeed that deep impressions are found at the sides of the thorax in well-preserved specimens of *Oggygia Buchii* and *Conocephalus Sulzeri*, separating the lateral lobes of each individual ring from its axis; but I should not be inclined to look upon these as sutures, which Emmerich declares them to be, because nothing of the kind is found in the other Trilobites; and there are no apparent means by which these lobes could have been moved (as their mode of insertion indicates that they might have been), since they could only have had a very slight muscular layer on account of the thinness of the lateral lobes. I believe, therefore, that the suture-like furrow alluded to does not indicate a suture, but originates from an acute angle, which projected here at the internal surface of the crust, between the

axis and lateral lobes; for, considering the entire absence of remains of the crust itself, there can be no question that in the impressions of both species we see the impression of the internal surface of the shell.

As little can I agree with Emmerich, who adopts the views of Audouin, that the lateral lobes consisted of two pieces, which correspond with the *episternon* and *epimeron* in the thorax of insects. There is not only no reason whatever for such a conjecture, but a decisive argument can be brought against it by referring to the fact, that the plates alluded to in insects are always portions of the crust, which encases the axis itself; while here they would appear as lateral projections, without forming part of the covering of the axis. Where there are no especial parts of the skeleton at each separate ring, as is the case with respect to the Trilobites, those names should not be applied which refer exclusively to such particular parts of the skeleton; nor should they even be made use of in the way of analogy if they were introduced to describe parts differently situated, for such a mode of proceeding will cause the utmost confusion.* In fact, I must repeat that the lateral lobes are nothing more than lateral continuations of the crust covering the rings of the body, that they are incapable of independent motion, and that they serve no other purpose than that of protecting the delicately constructed feet situated beneath them. On this subject I shall proceed to enlarge in the following chapter, and then endeavour to reproduce the absent organs of the Trilobites from the analogy of living forms of Crustacea; but it still remains to be mentioned with regard to the central parts of the body, (the real body rings,) that each generally consists of two semicircular protuberances, situated one behind another, of which the anterior and smaller one is hidden beneath the projecting margin of the preceding ring when the body is in a stretched position, but which can be very distinctly seen when the body is curved or doubled together. At the end of the furrow, which separates the two protuberances, there is seen at each side the articular cavity, which is nearly circular in the species of *Phacops* and *Calymene*, and rather transverse in *Asaphus* and *Illænus*: concerning the use of this I have already given the necessary information. We miss it entirely in all species and fragments deficient in the horny shell, since both parts, that is, the articulating process and the corresponding articular cavity, merely belong to the horny coverings. The transverse furrow of the central body, by which the anterior protuberance of each ring is separated from the posterior one, in most cases partially extends itself to the lateral lobes, and only disappears at the place where the latter bend themselves downwards by approaching to the posterior margin of the lobe, and

* Audouin, in his well-known work on the skeleton of insects, (Annal. des Scienc. Natur., Prem. Sér., tom. i, 1824,) calls that part of the skeleton *epimeron*, which is situated between the freely moveable paunch (?) and the back plate; *episternon*, on the other hand, he terms that part of the skeleton situated between the sternum itself and the back plate. Among the Trilobites, we find the only instance of these divisions of the external skeleton into separate pieces, in the head; in all the other parts of the body there is nothing of the kind. This circumstance is a most remarkable one; and it is without any analogy in living Crustacea, the shell of which always forms a continuation at the individual rings, and never consists of separated pieces, connected by sutures, not even when it distinctly covers several rings. Dalman has already recognized and published (Palæad. p. 13) an account of this exception from the general rule, that the skeleton parts of living Crustacea never have sutures; and I must once more particularly enumerate it as a most singular character of the Trilobites, although at the same time it is necessary to observe that the peculiarity which distinguishes the head-crust of these animals does not appear in the other rings of the crust.

passing over into the anterior angle of the arched margin of the lobe. I doubt very much whether the presence of this furrow on the lateral lobes is of any material importance in the organization of the Trilobites in which it occurs, for if this were the case, it could not be entirely wanting in some genera, for instance, in *Illaenus*; and I rather consider it as a secondary matter, caused by the presence of the transverse furrow on the central rings themselves, and thus continued to the lateral lobes. This view can be supported by the structure of *Illaenus*, in which the transverse furrow is as much wanting on the central principal ring as on the lateral lobes, and which therefore have a much flatter, and more uniformly arched back than the other species, the back rings being always individually very strongly arched. The organization of the abdomen of the *Macrura* furnishes among the living Crustacea an exact counterpart to the usual Trilobite structure with furrowed rings; while the organization of the thorax of the *Amphipodes* and *Isopodes*, on the other hand, represents the form existing in *Illaenus*. Both modes of formation, however, admit the power of rolling up, both by the Trilobites and by their living analogues referred to.

SECTION XI.

The number of rings, of which the thorax consists, is a circumstance of great importance. The number may be readily ascertained in those genera which have a large caudal shield, but with greater difficulty in those where the body terminates in a very small shield, in which only four rings are contained. The question arises here, whether the thorax can really be assumed as extending to this shield, or whether, judging from the analogy of living forms, a portion of the rings before the terminating shield does not belong to the abdomen, the real boundary of the latter being determined by the position of the sexual opening, as in *Apus*. Nothing of course can be decided in this respect, owing to the absence of all soft parts; and we have therefore no alternative but to consider the thorax in the Trilobites as extending to the simple caudal shield, and the rings contained in the latter as the abdomen.

Assuming then this to be the case, we find a very great difference in the number of the thoracic rings. The smallest number appears to be five;* Sars† at least asserts that he saw no more in *Asaphus rostratus*; whilst, according to Dalman, *Asaphus nasutus* possesses six rings; and since I am not aware of any authenticated case in which different numerical proportions of the rings occur in the same genus, I must assume that the first number is incorrect. The latter number is also found in *Cryptolithus*, Green; and *Trinucleus*, Murch. I have hitherto nowhere been able to perceive seven distinct rings; and although this number is stated by some authors as existing in *Ogygia*, the number of eight stated by others seems to contradict the correctness of this calculation. Eight articulations are possessed by all species

* Dr. Beyrich, in his 'Treatise on some Bohemian Trilobites' (Berlin, 1845, 4to), describes a perfectly preserved specimen of *Battus integer* with two body rings. This number therefore was the smallest.

† 'Isis,' 1835, p. 335.

of the genus *Asaphus* in their entire extent, also by *Ateges* and *Odontopleura*. Dalman enumerates nine rings in *Illænus centrotus*, but one ring might perhaps have escaped the attention of the observer, since they are so remarkably small in this species. With perfect certainty, I only find this number in *Archegonus* (De Koninck's *Phillipsia*). The true *Illæni* have ten rings. Dalman's *Calymene concinna* possess the same number, and if on that account only cannot belong to *Calymene*, nor can it indeed be referred to *Asaphus*, among which Emmerich places it. The species of *Phacops* have eleven rings, *Ellipsocephalus* twelve, *Calymene* thirteen, *Olenus gibbosus* and *Conocephalus* fourteen, *Olenus spinulosus* sixteen, and *Paradoxides bohemicus* has twenty rings. This seems to be the highest number of rings existing.

SECTION XII.

The abdominal or caudal shield (*scutum caudæ* s. *pygidium*), which we have next to describe, has already been mentioned as an extension of the coverings of the real abdomen, analogous to the cephalic shield, and has been exhibited as consisting of two layers, of which the upper possesses the same quality as the rest of the upper surface of the shell, while the latter more tender layer is marked with lines on its open surface in a similar manner. Between both of these, however, a thicker layer of the substance of the body must have existed. There remains therefore now only to treat of the axis of the shield, the true abdomen, in which we may also usually observe an articulation, although the rings are never so distinctly and regularly disposed as in the thorax. With respect to their distinctness, three stages may be enumerated, which may be termed the stage of perfect distinctness, of the indication, and of the deficiency of rings. The genera *Trinucleus*, *Ogygia*, *Calymene*, *Phacops*, *Eonia*, exhibit perfectly distinct rings. Very distinct rings are also to be observed in *Olenus gibbosus*. The arch of the ring itself in this case is continued to the lateral portions of the caudal shield, but the number of ribs is usually less by one or two than the number of rings in the axis; at least, I have counted only seven ribs in *Phacops latifrons*, while there are eight, or even nine rings in the tail, of which the last two are certainly very small, and merge into each other. *Calymene Blumenbachii* has always five ribs at the caudal shield, but seven distinct articulations in the tail itself. In *Ogygia Buchii* I have counted eleven ribs at each side of the caudal shield, but twelve rings at the tail itself, of which the last has a long oval shape, and in all probability consists of several articulations. *Phacops caudatus* has at each side seven ribs divided by a groove, and thirteen distinct articulations, besides an oval terminal articulation, which may be considered as a union of several articulations; *Phacops Hausmanni*, finally, has most of all, namely, nineteen to twenty-one in the axis, and thirteen to fifteen grooved ribs at each side. The terminal articulation of all the Trilobites is of a similar nature as described, and therefore probably only not articulated at the upper part, because the thick crust prevents the ring from becoming distinctly visible. In *Eonia* (*Gerastos* Goldf.) I have counted seven very distinct articulations in the axis, but I have not perceived any ribs at the side of the caudal shield; in *Olenus gibbosus*, on the other hand, six rings in the axis, and five on the shield, may with certainty be recognized.

Asaphus expansus s. *coriaigerus* belongs to the form with indistinct rings in the axis of the caudal shield; I have counted in it six short articulations, and a long, oval, terminal articulation. In another imperfect one, I believe I recognize nine rings, and a shorter, almost circular, terminal articulation. In *Asaphus tyrannus*, of which I know only the caudal shield, represented in Table V, Fig. 4, there are nine articulations, together with a long oval articulation. Indeed there seems to be an articulated axis, without elevated lateral ribs of the shield in most species of *Asaphus*, while the species referred to the group *Isotelus* might also belong to this, their articulation being merely very slight. I have seen no species of *Asaphus* without articulation at the axis.

On the other hand, we miss the articulation entirely in *Illaenus* and *Bronteus*, so that both these genera are representatives of the third form of the caudal shield.

The caudal shield corresponds almost completely in point of size and form with the cephalic shield in the genera *Asaphus*, *Illaenus*, *Amphion*, and *Trinucleus* or *Cryptolithus*; it is smaller in all other genera, because some of the body rings belonging to it in those genera have become isolated independent rings. Its size therefore decreases with the number of rings, and becomes smaller in the species of *Phacops*, *Calymene*, *Paradoxides*, *Conocephalus*, *Ellipsocephalus*, and *Olenus*, in the latter consisting only of one or two rings. *Ionia* or *Gerastos*, a genus which we have already mentioned as the type of a peculiar structure, is at the head of this series. A certain limit therefore seems to have been placed to the number of the body rings, and those of the abdomen seem to increase when those of the thorax decrease. Emmerich, indeed, has already considered this as the correct relation, but a more particular investigation does not confirm this view; and, indeed, the fallacy of such a conjecture may be proved by the mere comparison of the species of *Phacops* among one another, inasmuch as they never possess more than eleven thoracic rings, and yet fluctuate between nine and twenty-one in the number of their abdominal rings. The same thing is also seen in *Calymene*, but the limits of the series are not there so very different from one another, but merely fluctuate between seven and eleven. (*Cal. polytoma*, according to Dalman.) It appears, however, that the rings of the thorax and abdomen together do not generally exceed the number of thirty, and that in many Trilobites the number in both divisions of the body does not amount to so many, while the total number of rings is quite uncertain where the articulation at the abdomen cannot be recognized. For the rest, I have only to observe that the divisions at the axis of the head of Trilobites are likewise nothing more than indications of rings, but this can be easily reconciled with the view I have before expressed, namely, that they may be looked on as protuberances of the gill muscles situated beneath them, since as many body rings are always missed in all Crustacea as there are accessory pairs of gills at the head; from which it is evident that every pair of gills is affixed to a particular ring, the latter, however, losing its independency by its intimate junction with the head. Since also the number of lateral furrows of the head is never more than three, by which, however, there are never formed more than four protuberances, we might assume as many gills in the Trilobites, and suppose that in all cases where these protuberances are wanting, and where the anterior lobe contains all the others within itself, one pair of the gills must have grown very large (this would be the first pair according to analogy), whilst the others have disappeared, although they have not perhaps

been absolutely lost. But considerations of this kind belong to the following chapter, since I merely intended to describe the immediately recognizable structure in the present chapter, and this I believe I have now accomplished as completely and generally as possible.*

* The lobes of the cephalic protuberance, even if they are not complete divisions, might at once be termed rings; the anterior being denominated frontal or antennary ring; the second, the ophthalmic ring; the third, the gill ring; and the fourth, the labial ring; to which latter the accessory parts of the mouth were affixed. The transverse protuberance at the posterior margin, which is constantly present, and has already been mentioned as the articular border, might also be termed the articular ring.

CHAPTER II.

AFFINITY OF THE TRILOBITES TO THE EXISTING ARTICULATA.

SECTION XIII.

The fact that Trilobites are now generally recognized as *Articulata*, saves me the necessity of speaking at greater length with regard to their affinity with the *Mollusca*; such an investigation here being the more superfluous, since I have already sufficiently shown that the view is opposed by the general structure of Trilobites. For animals with eyes cannot be conchiferous molluscs,* certainly not, at least when they are furnished with two symmetrical compound eyes; and this is a characteristic which also removes them from the other orders of the Mollusca, and associates them beyond a doubt with the Articulata. Among the four subdivisions of the Articulata, the Insects and Arachnoids (the heteronomous or *Arachnidæ*, as well as the homonomous or *Myriopoda*) possess, however, so constant a type that it is impossible to associate the Trilobites with them; since even the apparently similar *Glomerides* are immediately to be distinguished from the Trilobites by the constant proportion of the numbers of their body rings, by the head not being shield-formed, by the absence of an abdomen or tail, by the aggregate of simple eyes, by the horny, articulated, numerous feet, and by many other characters. The Trilobites, likewise, cannot be worms (*Vermes*), the horny covering of their body, their compound eyes, and their heteronomous type being opposed to such a conjecture. They are therefore Crustacea, and that not only on account of those negative characters hitherto enumerated, but also on account of their positive and perfectly crustacean characters. To enable the reader to understand and to appreciate the latter, I shall preface this chapter by some introductory remarks on the systematic arrangement of the *Articulata*, and particularly on the characters of the Crustacea.

SECTION XIV.

Our present system of the animal kingdom is still tinged with one fundamental error, which consists in the circumstance that we exhibit individual characters as characters of groups, instead of determining the type, which is always imaginary, with scientific precision.

* When saying this, I would guard against being supposed ignorant of the fact, that numerous eyes have recently been observed in the species of *Pecten*. Previously to Krohn's interesting communication, I had read of this structure as probably belonging to these animals, in the 'Dict. des Scienc. Natur.' tom. xxxviii, p. 236.

I have endeavoured in various ways to meet this obstacle, and have already laid down the fundamental features of my system, which I have rendered as much as possible independent of every subjective mode of consideration, in my 'Hand-book of Natural History,' (Berlin, 1837-8, 2d division.) It would lead me too far here if I were now to communicate similar results, and it would also be unnecessary, since I have already published the principal facts in the work alluded to, and am even now engaged in carrying out the subject more in detail.* I will therefore merely state that the conceptions of the *homonomous*, and *heteronomous* systems of the articulated fundamental type are the characteristics which, according to my view, principally determine that type: the former notion intimating an always fluctuating, indefinite numerical proportion, the latter an immutable, constant numerical proportion either in all, or in some of the heteronomous divisions of the body. This numerical proportion in the latter case generally exhibits itself in the multiple of a simple combination, consisting either of the number *three* or *five*, the former being generally applicable to the lower heteronomous Articulata; the latter, on the other hand, to the higher. The class of Crustacea certainly exhibits an heteronomous type throughout, having no generally equal number of body rings, but a varying one corresponding, to its character as a transition group of the *Articulata*. The separation of the body into caput, thorax, and abdomen, of which each ought to be treated as an independent whole, according to peculiar laws, justifies the assumption of their *heteronomity*, which I consider as the most essential class-characteristic of the Crustacea. The two typical numbers, and as it appears generally, always the maximum number, predominate among the Crustacea in the *thorax*, which here, as among all other Articulata, presents the best systematic characters for the determination of the class. But the presence of these typical numbers, owing to the frequent absence of so many thoracic rings in the shape of isolated divisions, and also by the conversion of the organs of motion into accessory parts of the mouth, for the service of the head and of its organs, is frequently obscure on the first superficial observation. We must therefore, if we wish correctly to recognize the typical number of the thorax, always consider the accessory parts of the mouth as organs of motion, and these must add to the true organs of motion of the thorax, and then divide the total by 3 or 5, in order to arrive at the fundamental number and its multiple. This mode of proceeding soon leads us to the interesting result that all the higher Crustacea together with a constant type of antennæ, eyes, mouth, and organs of motion, also possess an equally unchangeable numerical proportion with regard to the rings of the thorax, which is always 2×5 or 10, and is therefore the simple multiplication of the second higher typical number; while, on the other hand, all the other Crustacea with fluctuating typical character of antennæ, eyes, parts of the mouth, and organs of motion, never exhibit the fundamental number of 5, but either possess no fundamental number which can be considered as generally peculiar to them, or at least as far as I have been able to convince myself by exact personal investigation, and in the majority of cases possess the number 3 in a formula of multiplication which fluctuates from 1 to 4.

The typical coincidence of both groups, already suggested in point of several characteristics, renders it possible to define them with still greater certainty than this can be done

* I intend to publish this work shortly, under the title of 'An Attempt at a Rational Zoology.'

from the mere numerical proportion, and to establish the following general characters of them: namely, the Crustacea with the numerical proportion 2×5, have always two pair of antennæ, compound eyes with facetted cornea, no simple eyes (with a few exceptions, however, as in *Mysis*), articulated walking feet at the thorax, and always fin feet at the abdomen when this part of the body is present; the number of articulations never less than three, or exceeding seven. They form the group of the *Malacostraca* of former modes of division.

The Crustacea with the fundamental number of three, have fewer general characteristics, owing to the very circumstance that they represent a lower division, but I have always found in them compound eyes, with a simple, smooth cornea;* sometimes also simple eyes, or (occasionally) only the latter, and then in a simple number, especially when young; they generally have fin feet, and usually in that case no feet at the abdomen, which is frequently very short, but in some cases very large: there is further a remarkable uncertainty in the formation of the antennæ and organs of the mouth, the type of which, therefore, is fluctuating. All run through different stages of metamorphosis, and exhibit much greater differences in the respective periods than the members of any other division. I call them *Ostracodermata*.

The metamorphosis with its various differences seems to be the circumstance which deserves particular attention in the subdivisions, inasmuch as it exhibits itself partially as retrogressive,† partially as progressive. The retrogressive metamorphosis is not peculiar in an equal degree to all members, since it is occasioned by external circumstances; and with regard to retrogression, as there is in reality no such process in nature in a strict sense, it cannot be a general character of the whole group, but only an indication of some members of certain sub-groups. If therefore I avail myself of it as a mode of division, I do it only in the same manner as oviparous propagation is mentioned, as a partial characteristic of some of the cold-blooded vertebrate animals, although it does not exhibit itself in all in the same way. The *Ostracodermata*, then, are divided into two groups, and each group in three tribes. The absence of a distinct head with true antennæ and eyes is as characteristic for the first group, among the members of which a retrogressive metamorphosis is peculiar, just as the presence of very large, frequently monstrously developed eyes is exhibited with a progressive metamorphosis; and in the same way also very powerfully developed antennæ, especially if the eyes become smaller, is characteristic of the second group. The further differences consist in various peculiarities, the explanation of which in detail would occupy too much time; but I have put them together in a tabular sketch, and by indicating all the higher groups of Crustacea in this table, according to their most important typical characteristics, I have enabled my readers to determine by their own observation how far the *Trilobites* are related to each, and with which group most intimately. (See the Table, p. 34.)

* In several species, for instance, in *Limulus*, it appears facetted when in a dried state, but again becomes smooth by being softened with water.

† The phenomenon of the retrogressive metamorphosis, on which Rathke has recently written more specially, I had availed myself of as a mode of division when giving lectures at Berlin, and have published this view two years ago, in Ersch and Gruber's Encyclop., vol. xxv, section i, p. 119.

CRUSTACEA.

Articulata with a heteronomous type, with peculiar, and generally articulated organs of motion which are provided with gills, if respiratory organs exist at all. No constant equal numerical proportion predominates with respect to the parts of the thorax; but there are various multiples* of a combination, which consists of either 3 or 5 members.

I.—OSTRACODERMATA.

The fundamental number of rings of the thorax is *three* (query always?), and the multiples of it vary from 1 to 4. The compound eyes have a simple, smooth cornea. The young of all the species are monoculous, and generally have only antennæ and palpi as organs of motion. They undergo a metamorphosis, and are essentially inhabitants of the water.

Order I.—*Prothesmia* or *Pseudocephala*.

At a mature age they generally have no eyes. The number of thoracic rings, when they can be distinctly traced, are 2 × 3. The abdomen is wanting, or there are no organs of motion. The metamorphosis is *retrogressive*.

A. With a hermaphrodite structure, and gills without palpi.

Tribe I. *Rotatoria.*

Unarticulated, wart-formed organs of motion, with cilia or bristles. Rectum and genitals opening in one cloaca; abdomen rarely wanting; formed of several joints, and not pierced by the intestine; eyes simple or none; metamorphosis none or imperfect.

Tribe II. *Cirripedia.*

Six pairs of articulated cirriform organs of motion. Openings of rectum and genitals separate. No abdomen, no antennæ, or eyes. Metamorphosis complete. Always fixed when aged, and encased by a thick shell or membrane.

B. Sexes separate; gill with palpi.

Tribe III. *Siphonostoma.*

The mouth is formed, more or less, in the shape of a beak; two pairs of antennæ before the mouth, and six pairs of organs of motion behind it, if they are all perfect. Affixed or moveable parasites, with metamorphosis—most of them with an abdomen of three joints.

Order II.—*Aspidostraca* or *Entomostraca*.

They always have eyes, and generally antennæ. The number of thoracic rings varies from 1 to 4 × 2. The sexes are separate; the metamorphosis is *progressive*. They never affix themselves, and are never parasites.

A. Nothing but homonomous organs of motion, only calculated for rowing; true gills, and from 1 to 3 pairs of accessory parts of the mouth

Tribe IV. *Crophyropoda.*

Feet articulated, simple or cleft in two, with long bristles. Number of rings 1 to 3 × 3.

a. Gymnota s. *Copepoda.*

Without any material shell, with articulated thorax, and articulated abdomen. Long feelers

b. Ostracoda.

With a large bivalved shell, simple eye, and unarticulated abdomen; short antennæ

Tribe V. *Phyllopoda.*

Feet consisting of unarticulated, cleft, fringed, membranous lobes. Compound and simple eyes; articulated thorax and abdomen. Number of rings in the thorax 1 × 3; in the abdomen 2 to 6 × 3.

a. With a shell.
α. Shell double lobed.
Limniadidæ.
β. Shell shield-formed.
Apodidæ.
b. Without a shell.
Branchipidæ.

B. Ambulatory feet at the thorax, gill feet at the abdomen; the latter at the same time feelers and gills. Numerical proportion in both divisions of the body 2 × 3. Compound and simple eyes. Articulate thorax and abdomen, each covered by a large shield-formed shell.

Tribe VI. *Pæcilopoda.*

II.—MALACOSTRACA

The fundamental number of rings of the thorax is *five*, and its multiple is always the simple duplication (2 × 5). The compound eyes have a facetted cornea, and there are no simple eyes. The young ones resemble the old, entirely or partially, and the metamorphosis is *progressive*. Organs of motion always double, and the abdomen always furnished with fins.

Order III.—*Thoracostraca* or *Podophthalma*.

Head immoveable, with pedunculated moveable eyes; thorax entirely, or for the greater part, covered by a simple shell. Abdomen always having *seven* joints.

Of the 10 rings of the thorax 5 bear accessory parts of the mouth, therefore only 5 walking feet, the number of which on that account is 10. Form, 5 × 5. Decapoda.

Tribe VII. *Brachyura.*

The fin feet of the last ring but one of the abdomen are never used for the formation of the terminal fin, but are entirely wanting. The abdomen is closed against the thorax.

Tribe VIII. *Macrura.*

The fin feet of the last ring but one of the abdomen are stretched towards the posterior part, and form a large end fin. Abdomen usually not closed, but extended.

Of the 10 rings of the thorax only 2 bear accessory parts of the mouth, therefore 8 feet, of which the most posterior ones, or all of them, resemble fins. Form 2 × 8. Gills variable, but generally on the abdomen. The latter furnished with a large caudal fin.

Tribe IX. *Stomatopoda.*

Order IV.—*Arthrostaca* or *Edriophthalma*.

Head moveable, but the eyes immoveable; no common shell of the thorax. Of the 10 rings of the thorax 3 always bear accessory parts of the mouth; likewise 7 walking feet. Formula, 3 × 7.

Tribe X. *Amphipoda.*

Body compressed at the sides, with variously formed feet. Abdomen always furnished with *seven joints*, with end fins, but without gills, which are only seated at the thorax. The young ones perfectly resemble the old, excepting only in size.

Tribe XI. *Læmodipoda.*

Body round or flat; the fourth ring closely jointed to the head; therefore only six free rings remain. Abdomen wanting, or furnished with one joint, and very much shortened.

Tribe XII. *Isopoda.*

Body flatly pressed; always seven free rings, with rowing or walking feet. Abdomen small, consisting of from one to seven joints, with fins bearing gills. Many of them are parasites, and in that case have rudimentary eyes and organs of motion. The young ones only possess six walking feet, and the last pair follows afterwards with the ring of the body.

REMARK.

The Isopoda that live on the land have aggregates of simple eyes.

* This circumstance is most important, inasmuch as all the other heteronomous articulata possess the fundamental number only *once*. Owing to this, they always have a greater number of rings for the abdomen, whilst in the Crustacea the number of rings for this division of the body is always much smaller, or at the utmost, equal to the number of rings of the thorax; the only genus forming an exception to this is *Apus*.

SECTION XV.

A correct estimation of the characters exhibited by the *Malacostraca* will prove to us at once that the Trilobites cannot, at all events, belong to this second principal division of the Crustacea, for they have neither facetted eyes (see Sect. V), nor a common thoracic shell, nor a constant number of (from five to seven) thoracic rings, which would necessarily belong to them if the thoracic shell were wanting; at least, the number could not be exceeded.* This view, however, is likewise further confirmed by the absence of feelers with a horny shell, by the enlarged, shield-formed head, by the absence of visible articulated equal feet, and by the unequal numerical proportion of the abdomen, which is covered by one common shield. Thus we disprove the affinity of the *Trilobites* with the *Isopoda*, and especially with the genus *Serolis*, which was insisted upon by so many of my predecessors. In order to manifest the incorrectness of such affinity to every one, I have represented *Serolis paradoxa* (*Oniscus paradoxus*, Fabr.) side by side with species of the *Phyllopoda* (Table II, Fig. 2), and I think that the mere inspection of these different forms must convince every unprejudiced person that the opinion of the affinity of the Trilobites with *Serolis* cannot for a moment be entertained. No single genus of the Trilobites has exactly the same numerical proportion, nor, indeed, is there any other similarity with *Serolis*, excepting that which is founded in the general class characteristics, and I must therefore, most decidedly, declare myself against the arrangement of the Trilobites among the *Malacostraca*, being unable to perceive a single reason in favour of such view. Indeed, even the moveable lateral lobes at the thorax rings of many of the *Isopoda* cannot be compared with the lateral lobes of the Trilobites: first, because they are moveable; and secondly, because they belong to the leg, properly speaking, and represent the modified hip of the latter, as I shall subsequently prove; I will here only remark that all the *Isopoda*, in which the moveable lateral lobes are wanting, possess in lieu of them a fundamental joint on each leg above the hip, which represents the rudiment of a lateral lobe.

It can also be shown with as little difficulty that the Trilobites have nothing in common with *Limulus*, excepting a very superficial resemblance. The absence even of a separated head and thorax in this genus would render the affinity impossible; the hard, powerful, horny feet, however, which have been so well preserved among the petrified *Limuli* of the Jura formation, and which, therefore, we cannot doubt would be seen also in their analogues of a more ancient period, are a still greater reason against it. The well-known power in the Trilobites of doubling themselves up would have been a very unnecessary gift, if they had had legs like those of the *Limuli*, since the latter are much too large to admit of their being concealed when folded, and the animal is much too powerful to require the protection afforded by that process. Nevertheless we must admit that the general form of the cephalic shield, the absence of antennæ, the position of the eyes, and the existence

* Some *Arthrostaca*, as also the *Læmodipoda*, have only six thorax rings; some *Isopoda* (Pranizæ) only five, but no member of this group exhibits more than seven. Those exceptions, however, can readily be explained, and their origin traced.

of a simple shell of the abdomen, present facts in favour of an analogy existing between the two groups, which ought not to be overlooked, and which place the Trilobites much nearer to this genus, than among the *Malacostraca* near the *Isopoda*.

SECTION XVI.

I think I have now shown that the Trilobites can only belong to the first principal group of the Crustacea, or to the *Ostracodermata;* the only question being with which of the two orders assumed in this group, it stands in the nearest relation. The reply to this question will follow of itself, when we observe that the Trilobites in an advanced stage of life possessed large eyes, and on that account must have had considerable locomotive powers, so that beyond all question they must be *Aspidostraca* or *Entomostraca*. This result can be distinctly proved by the following reasons:

1. All *Aspidostraca* have compound eyes with a smooth cornea, the Trilobites likewise.

2. They are frequently covered by large shells, which widely project over the axis of the body; the Trilobites possess quite an analogous formation of the shell.

3. These shells consist of two membranous layers, with a thin stratum of the substance situated between them. The lower layer is much more tender than the upper, quite in the same manner as we have found it among the Trilobites.

4. The *Aspidostraca* possess tender, soft feet, very easily injured, and such must have been possessed by the Trilobites, to account for their absence in all the fossil remains of the latter.

5. They are exclusively inhabitants of the water, and only move by swimming; the habits of the Trilobites must have been similar, because they have no hard organs of motion suitable for crawling.

6. The *Aspidostraca*, at least those covered by shells, have usually very small antennæ, or none at all, while among the *Malacostraca* they are very large, and covered by a hard upper membrane. This explains immediately why we miss these organs in the Trilobites.

7. The different subdivisions of the *Aspidostraca* exhibit different numbers of body and caudal rings, and correspond partially in this respect with the numerical proportions of the Trilobites. The fundamental number of the thorax divisions is exactly the same among all *Pseudocephala* and *Malacostraca*, and differs only relatively, according to the greater or lesser number of rings which have become combined in the head.

It appears unnecessary to seek for any further reasons in proof of the affinity of the *Trilobites* and *Aspidostraca*, after having exhibited so many important points of similarity between them; I therefore now conclude this investigation with a short consideration on the true relations of affinity which probably obtain between the two groups alluded to.

SECTION XVII.

At the commencement of this discussion, and as expressing the view which I shall endeavour to prove, I make the following statement:

That the Trilobites do not belong to any of the still living families of Crustacea, but represent a distinct group most nearly related to the *Aspidostraca;* that their organization, however, exhibits peculiarities, which at the present day do not occur together in one family, but are dispersed in several heterogeneous groups; thus, although we have proved in the preceding paragraph that the Trilobites correspond in many essential points of organization with the *Aspidostraca*, and are not related to any of the still living groups of Crustacea, yet we must not neglect to observe that various important and even typical differences take place between *Aspidostraca* and *Trilobites*. These differences consist principally in the numerical proportions of the thoracic rings, since although the latter certainly vary among the *Aspidostraca*, they may yet be reduced to several constant fundamental numbers (6, 9, and 12); whilst the Trilobites only exhibit a constant number of rings for each separate genus, and the total number cannot be reduced to certain, unchangeable, fundamental numbers or numerical types. In attempting to ascertain with certainty the number of thoracic rings, we certainly meet with the obstacle that we do not know, nor ever can know, the position of the sexual openings among the Trilobites, which position alone indicates with certainty the boundary of the thorax. But even if we exclude for the present the *Olenoides* with their many-articulated body, and in which the capacity of doubling themselves up is wanting, (since there is the greatest probability that in them the sexual opening was not situated at the last ring before the caudal shield, but on a preceding ring,) yet in the other genera we have the constant numbers 6, 8, 9, 10, 11, and 13, which cannot be reduced to a common fundamental formula. If, therefore, we do not assume that the sexual opening in these genera was also situated at a certain ring of the body before the caudal shield,—say for example's sake at the sixth (2×3), or ninth (3×3),—we find ourselves obliged to adopt the view that the Trilobites, in point of the fundamental numbers of their thoracic rings, are not constructed according to the law which we have discovered to obtain amongst all Crustacea of the present world.

This is a most important result, and it perfectly confirms the opinion which I have already pronounced several times, that the ancient types of organization do not correspond with the existing ones, but that they more or less deviate from the plan of the present creation.

Cuvier, indeed, has acknowledged the truth of this principle, but he did not carry it out; it has subsequently been often touched upon, especially when speaking of extinct amphibious animals, but, so far as I am aware, it has not even yet been fully recognized by any naturalist. The consideration of this subject is, notwithstanding, the means by which we should be able to show most distinctly that the organized beings of our earth were originally created according to one uniform plan, but that the nature of this plan with regard to the different types, was at first by no means so clearly and distinctly established as it appears to us now in the present representative species. The earlier types, in fact, seem to present the various peculiarities of several groups passing into one another, resulting in forms

which exhibit in association, although incompletely, the peculiarities now found detached and characteristic of very distinct groups. Minute and careful observation has seemed to confirm this view, and exhibits also another important fact, namely, that in proportion to the geological age of the extinct species, the running of the various typical forms into one structure is more marked, and therefore the peculiar and organic individuality and distinctiveness less obvious.

Such being the case, it will no longer appear strange that the Trilobites, the oldest Articulata that we are acquainted with, should not exactly correspond with any one group of living Articulata; and, on the contrary, it would rather be a matter of surprise if such were the case, for their identity with any recent family would overturn those laws which have been developed with so much labour and care in the course of various researches on the organic beings of a previous creation. If therefore any one should assert that the identical representative had been discovered of an animal whose period of existence in a living state was unquestionably very remote, and long antecedent to the commencement of the present era, we might safely assert, wherever the discovery was said to have taken place and even without seeing the supposed representative, that it is not what is thus assumed. No doubt the assertion might be credited by many imperfectly informed persons without due investigation, but the naturalist acquainted with the unity and uniformity of the great plan of Nature, and her method of producing results by laws which are invariable, will not for a moment entertain a belief of the present existence of any species of Trilobites, however comparatively insignificant the creature may be.

I would by no means assert, however, that Trilobites wholly deviate from the types of all existing Crustacea, for, on the contrary, many important resemblances are found, which I have already indicated and partially explained. We are even able, by a careful and accurate estimate of these resemblances, and by comparing the details of structure exhibited in the remains handed down to us, to restore those points in the organization that are wanting by considering the affinities with recent forms. It is this task which I now proceed to perform.

SECTION XVIII.

In order to proceed with due caution it will be proper, however, first to explain more particularly the peculiarities of that group of Crustacea with which the Trilobites are most nearly related, for the purpose of being able to infer thence whether they may possibly stand in a more intimate relation of affinity to any one subdivision of the group, or whether they exhibit a similar relation to all. According to the tabular sketch already given, the group of Aspidostraca is divided into three tribes, bearing the names of *Lophyropoda*, *Phyllopoda*, and *Pœcilopoda*. These denominations indicate important differences with regard to the feet; for the first two divisions possess soft, membranous organs of locomotion, solely calculated for swimming; while the *Pœcilopoda* possess hard, articulated, walking feet, and in this group serve also as gills, and aerate the blood. This circumstance has already been taken into consideration, and an important difference between the animals of this group and the Trilobites has been thence inferred. The genus *Limulus*, which con-

stitutes this group, corresponds only in some peculiarities of the cephalic shield or of the cephalothorax with the Trilobites, and for this reason, and since it is only a partially analogous form, I shall not say more concerning the group.

Of the two other groups, the *Lophyropoda* generally exhibit a slighter or less compact form of the body, and rather large antennæ; they also have either a single eye, (which in some species is large, in others small), or two very small eyes, and therefore exhibit characters which correspond less completely with the type of the Trilobites than the more considerable size of body, larger eyes, and undeveloped antennæ of the *Phyllopoda*; I therefore do not hesitate to recognize in the latter the nearest affinities of the Trilobites, for which reason I shall now describe their organization more particularly.

SECTION XIX.

The *Phyllopoda* have a soft, fleshy body, the thorax generally consisting of eleven members, bearing the same number of fin-shaped organs of motion. The head is an independent division, to which, besides the antennæ and organs of mastication, a rudimentary pair of feet is attached, by which the number of feet of the thorax is increased to twelve (4 × 3). The other organs vary; there are generally two pair of antennæ before the mouth, but these are either remarkably small, as in *Apus*;* or only one pair consists of distinct antennæ, whilst the other is prehensile, and assists in the act of copulation, as in *Branchipus*; or else, lastly, the former pair of antennæ assists in locomotion as a fin-foot, while the latter is a short, almost jointless, lobe of flesh, as in *Limnadia*. The eyes present similar differences. There are two large compound eyes, and one simple eye, in all *Phyllopoda*, but the former are either planted on a long peduncle, and are moveable, as in *Branchipus*, or are immoveable, and in that case partly united in a circular form, as in *Limnadia*, and partly arranged in two distinct semicircles, as in *Apus*. The simple eye stands between them at the extremity of the forehead, or if they are close to each other is behind them. It is remarkable, however, that *Branchipus*, the genus having large, greatly projecting, moveable eyes, does not possess any protecting covering, whilst *Apus* and *Limnadia* are so provided, the protecting envelope in the former of these genera (*Apus*) consisting of a head plate enlarged into a shield, which only, indeed, covers the head, but is intimately connected with the body of the animal; while in the latter, on the other hand, (*Limnadia*), it consists of a shell formed as in shells with double flaps, and this shell is placed at the junction of the head and body, (and therefore, properly speaking, also at the head,) and can be opened and shut below at the will of the animal. Another important relation harmonizes with the presence of this shell, namely, the structure of the abdomen, which in the genera covered by shells, exhibits no marked distinction from the thorax; and even (which is the only case in the whole class of Crustacea) bears feet constructed in exactly the same manner, only successively smaller, and not merely is there a single pair at each ring, but at first two at each, and afterwards even three or four. The number of organs of motion is

* *Apus*, *Branchipus*, and *Limnadia*, are represented in Table VI, Figs. 1, 3, and 15.

thus increased in an extraordinary degree, and the difference between thorax and abdomen disappears entirely on a superficial observation. It is only the internal anatomical examination which determines the boundary of the two divisions, and exhibits the sexual opening behind the eleventh ring, but this is seen even in *Apus*, exactly at the same spot at which it is situated in *Branchipus*. The two last rings are, however, excepted from this remarkable and unique instance of the approximation of the abdomen to the type of the thorax, these rings retaining the shape of the abdomen, but bearing no further organs of motion, and terminating with simple horny appendages, as in *Limnadia*, or with articulated ones as in *Apus*, and these are attached to the remarkably developed last joint of the body. Between them is the anus. *Branchipus* shows no trace of any of these characters, its abdomen, consisting of nine joints, has no feet; and instead of the horny appendages, we find in them either two large soft caudal fins, or, as in *Artemia*, nothing whatever to represent them; but the females here also possess distinct egg-capsules at the commencement of the abdomen, and the males smaller seminiferous sacs. Nothing of this kind, however, is found either in *Apus* or in *Limnadia*; the males in the former bearing such a resemblance to the females, that the former a few years ago were not known at all,* and Mr. Kollar, of Vienna, was the first who discovered them;† while in the latter the males possess organs of copulation in the first modified part of the thorax, (or at least this is the case in a species which has in consequence been detached to form the new genus *Estheria*). The females of *Apus*, however, can easily be recognized by the sacs, which are situated at the eleventh pair of feet, and which serve as the repository of the eggs, but are placed towards the back, beneath the shield.

The feet of these animals exhibit also a difference corresponding with that presented by the structure of the body, both in the case of those which have shells and which are without such defence. They consist in all cases of soft, membranous lobes, which are merely supported by muscular bundles, the circumference of which is intersected at intervals irregularly, and at the margin they are covered with long, fine, hairy fin-bristles. At the inner side six principal lobes are seen, of which the first four are of nearly equal size in *Limnadia* (Fig. 15, B); but in *Apus* (Figs. 9, 10, 11) the first (B) differs very much, and the succeeding ones resemble one another, only they become larger from the basis to the point. In *Branchipus*, however (Fig. 12), they become smaller in the other direction; and the fifth lobe, the last but one, which is very long and small in *Limnadia*, is very broad and rounded in *Branchipus*, and in *Apus* is similar to the preceding lobes. The last, the sixth, lobe is connected by a special joint with the rest of the foot, and is therefore more freely moveable; it has a long stretched, rudder-like form, and seems to be the most important of all the divisions of the foot. Every foot, at the opposite outer side, bears a bladder-formed gill (K, in the plate), and is also provided with broad lobes of membranes. Of these we only find one very large lobe beneath the gill in *Apus* and *Limnadia* (L); but in *Branchipus* there are two lobes (which, however, are both situated at the gill), one of them a large one,

* In a work, otherwise very excellent, by E. G. Zaddach, (de Apod. cancriformis anatome et evolutione, Bonn, 1841, 4to), these animals are described as hermaphrodites, which probably is only to be attributed to a defective microscopical analysis of the organs of generation.

† 'Isis,' 1834, p. 680; Froriep's 'Notizen,' 1833, vol. xxxviii, p. 148, etc. Mr. Kollar had the kindness to present me with a male specimen.

similar in circumference to the latter, and placed next to it (Fig. 12, L); and the other smaller, and situated rather higher upwards (I). The gill is easily known by its bladder-like form, by the want of muscles extending towards or penetrating into it, and by the absence of fin-bristles at its margin; while all the other lobes are surrounded both by fin-bristles and are also supported by muscles, which latter extend towards them, and serve to assist in locomotion. The lobes of the outer side, although the largest, are yet the most delicate and the least protected; they are, however, furnished with muscles, and they therefore appear to be more intended for the protection of the gill, than for locomotion. This is further confirmed by their inverted position in relation to the gill in the case of those genera covered with shells, as well as in the naked genera. I would therefore call them "protecting lobes."

There is no doubt that the absence or presence of a shell is the main distinctive character of the group; and since a classification in which the natural characters are placed in opposition becomes necessary, I have planned the following formula:

First Group.

Genera with Shells.

Characters.—Eyes immoveable, placed closed to one another. The rings of the body partially spinous: those of the abdomen likewise bear feet; the last is a horny capsule, furnished with various appendages. Gill of the feet attached above the protecting lobe.

Division A.—*Shell with two Flaps.*

Eyes united into a circular group: anterior antennæ having two rows of filaments, posterior simple;—all the antennæ at least as long as the head. No accessory parts of the mouth, fifteen abdominal rings, the moveable terminal spines unarticulated.

Genera.—Limnadia, Estheria.

Division B.—*Shell, Shield-like.*

Eyes crescent-shaped, more distinctly separated; the antennæ scarcely recognizable; two pair of accessory parts of the mouth behind the jaws; first pair of feet (not including the real first, but rudimentary pair) furnished with four long, many-jointed fibres, instead of the fin-lobes; abdomen formed of more than fifteen rings, the terminal spine of the last ring long, moveable, and articulated.

Genera.—Lepidurus (with a flap between the end bristles), Apus (without this flap).

Second Group.

Genera without Shells.

Character.—Eyes pedunculated, moveable. Antennæ unequal; the anterior consisting of simple fibres; the posterior tongue-shaped, and serving as organs of copulation. No accessory parts of the mouth behind the jaws; the gills of the feet beneath the protecting lobes; abdomen without feet and smooth; ovarian and seminiferous sacs, external.

Genera.—Branchipus (abdomen furnished with nine joints, with two caudal fins. Artemia (abdomen furnished with six joints, with two terminal lobes).

SECTION XX.

The near analogy of the *Trilobites* to the *Phyllopoda* appears to me to be especially illustrated by the points of resemblance already alluded to; viz. the double large eyes, the undeveloped antennæ, and the very soft membranous feet. But *Branchipus* seems to be that form among them, with which the organization of the Trilobites has the nearest affinity. In order, however, to render this quite manifest, I have drawn the shell of a Trilobite round the body of a *Branchipus*, and thus obtained an imaginary form (Fig. 16, Table VI); which, I think, will scarcely leave a doubt respecting the near analogy of the two forms. Referring to this figure, the real head will be seen projecting from the cephalic shield, but with this difference in *Branchipus* that in it the projecting boss forming the head consists of only two divisions, the anterior of which, bearing the antennæ and eyes, is smaller than the posterior, to which the branchial apparatus and accessory parts of the mouth are affixed. In Trilobites, on the other hand, the projection of the head is either simple or divided into four parts, and in the latter case the first is either the smallest, as in *Olenus, Triarthrus, Trilobites Sternbergii*, and other allied forms; or, as is sometimes seen, the first is the largest, the others being all smaller. This proportion indicates very large eyes and antennæ, a view which seems verified in the case of the genera enumerated, since even the so-called species of *Olenus* have small eyes, while *Asaphus, Illænus*, species of *Phacops*, and *Oggyia*, have very large ones. For the same reason we might also draw an inference from the development of the antennæ, and assume that one pair of them perhaps, as in *Branchipus*, were organs of copulation. I consider myself further justified in this assumption by the structure of the lower side of the head; for a very large, broad, cephalic shield, such as that seen in *Asaphus* (Table VI, Fig. 8, *a*), and *Paradoxides* (Table I, Fig. 7,) indicates developed organs towards its side. The anterior enlargement beside it (Table VI, Fig. 8, *b*, *b*) may perhaps have been the pedunceles of linguiform antennæ, or the latter may have been attached to the lateral enlargement beside the cephalic shield (Table VI, Fig. 8, *c*, *c*), while the anterior enlargement bore small, short, true antennæ, as in *Branchipus*. If this conjecture is well founded, we may also easily understand why the anterior division of the head of the Trilobites is so large, sometimes even (as, for instance, in *Phacops*—Division A,—and *Asaphus*) obliterating the succeeding divisions, and thereby causing an undivided projection of the head. The wide-arched space of the shield beside the projection of the head beneath the eyes, would also be very well calculated for the reception of such linguiform antennæ. The moveable upper lip was unquestionably affixed to the posterior margin of this lower projection of the head (the real *Clypeus*, Table VI, Fig. 8, *d*), and the size of the lip depended on the width of this margin, and on the magnitude of the incision. As in *Apus* and *Branchipus*, this lip covered the upper jaw, the form of which perhaps rather resembled the upper jaw of *Apus* than that of *Branchipus*, since the hard horny shell also indicates more solid organs of mastication. The third division of the projection of the head, which is generally the largest after the first, probably corresponds with the position of the jaws, and formed the basis of attachment for the muscles. It represents that ring of the body which, in the typical form, is independent, and has the organs of locomotion changed into gills; and since only a

smaller division exhibits itself behind this one, and anterior to the articulation of the succeeding one, we might thence infer that there were accessory parts of the mouth, an inference which is highly probable, since in *Apus* there are also two pair of accessory parts of the mouth at that spot. The structure of *Limnadia* and *Branchipus*, neither of which possesses any true accessory parts of this kind, exhibits, however, an indication that these may likewise have been wanting in those Trilobites characterized by a simple projecting head. Such genera are *Asaphus*, *Nileus*, *Illænus*, *Trinucleus*, *Oggygia*, and *Phacops* (Division A), all of which are Trilobites in which a pair of small bosses are always exhibited more or less distinctly behind the large, simple projection of the head. These little bosses seem to indicate the traces of the rings to which the jaws were attached, but I should be inclined to question the existence of accessory parts of the mouth in all such Trilobites; and this affords a decided reason for separating the species of *Phacops* referred to Division A, even generically, a view which is also favoured by the whole structure of the body.

It will now probably be admitted that in the structure of the *Phyllopoda* may be recognized the typical characters exhibited in the general configuration and proportions of the head in Trilobites, and that those writers have been fully justified who have considered the two groups as related and nearly analogous. It will be seen as we advance, that there are still additional reasons in support of the view I have taken, especially when we come, in the next place, to consider the structure of the feet, since the varying numerical proportion of the rings which compose the body of Trilobites separates the group from *Phyllopoda*, where this number is constant ($4 \times 3 - 1$).

SECTION XXI.

There is good proof that the feet of the Trilobites must have been soft membranous organs, for the absence of the slightest remains of these organs in the numerous specimens observed is of itself sufficient evidence of the fact,* and it can indeed scarcely be supposed that hard horny extremities should be affixed to a soft membranous abdominal surface; since they would not have then possessed that firm basis, which all solid organs of locomotion require, in order that they may be properly available. That this abdominal surface also must have been of a membranous nature seems quite clear, since it has in no instance been preserved in a fossil state, whilst the hard, horny, perhaps calcareous, dorsal surface is invariably retained, and there can be no reason why the latter only should have been handed down, if the former was also hard. We may then safely conclude that it was soft and easily destroyed, and I would only have the reader refer to the rings in the tail of the Crustacea, formed in a manner very similar to that observed in the case of the Trilobites, in order that he may be convinced that if there had been hard and solid coverings of the

* Eichwald (l. c. 39), Goldfuss, and Count Sternberg, as is well known, fancied they recognized feet in the remains of some Trilobites; but the representations and descriptions they have given are too indefinite to enable us to draw any certain conclusion. Eichwald's description certainly mentions the number of joints (five) and the size of the foot (four lines) with greater exactitude; but even then it is very unsatisfactory and obscure.

abdomen, they must have been, as in the other Crustacea, directly attached to the hard upper shell, in order that there should be a sufficiently solid basis for the organs of locomotion. But we may well inquire how all such solid girdles inclosing the abdomen could, if they ever existed, have been broken off with such perfect regularity that they have not even left a single vestige. Such an assumption is beyond the bounds of probability, and yet we must suppose this to have been the case, if we suppose that the abdominal surface of Trilobites was provided with a solid covering like that of the back, and the assumption is equally necessary if we believe these animals to have had hard horny extremities, since such extremities are never found in the Articulata unless accompanied by a solid thorax.

Considering then that all traces of the extremities are absent, we may be permitted to assume that the feet of Trilobites were too soft and delicate to have left even their impressions, and this is precisely what might have been expected, if my view of the affinity of these animals to the *Phyllopoda* is correct; but although this, and other reasons already given, might of themselves be considered sufficient to establish the fact, it may be proved yet more distinctly by referring to the power possessed by most species of the extinct family to double themselves up, a faculty often exhibited in the specimens found fossil which have been preserved in this form. In performing this evolution the animals in question arched the back, and bringing the caudal shield in contact with the under part of the head, concealed all the abdominal surface beneath the hard horny coating of the upper side. Now there is no imaginable reason why the animal should have been endowed with a power of thus rolling itself into a ball, if the under side of the body were defended with a horny or solid shield; but we can well understand the importance and meaning of it, if the under side were, as we suppose, undefended, for it is then a simple effort of nature to protect these soft and vulnerable parts against external violence. It may, indeed, be said that some genera, such as *Odontopleura*, *Ogygia*, *Olenus*, &c., were not endowed with this faculty, and that therefore no general inference can be drawn, but this, in point of fact, is not a valid objection, since it appears, from the frequent absence of all remains of the hard covering in the case of these genera, that their shells must have been softer and more tender than the shells of other Trilobites, and I think there is reason for concluding that this was the case, from certain specimens which I have observed and examined of *Olenus gibbosus* from the alum slate of Andrarum. In this case, if the shell were thus thin and tender, as in *Apus*, the power of doubling the body together into a ball would have been useless, as it would offer no protection. Indeed, in these cases, the lateral lobes are so constructed that undefended spaces would have been left if the body had been doubled, so that no advantage would have been gained. We may therefore conclude that even in those cases where the body does not appear to have been capable of being doubled up, the feet were still soft, and we may venture to assert that in the *Olenidæ* the impressions of the feet themselves would have been found, if they had been as hard as or harder than the soft covering of the body of these animals.

Proceeding, however, with the comparison, let us now consider the structure of the extremities of the living *Phyllopoda*. They exhibit, as we have already seen, only one principal type, modified with regard to the arrangement of the gills, and this modification depends on the presence or absence of a horny or calcareous covering of the body. Among the Trilobites whose body was provided with a shell on the upper surface, and which were

even protected by lateral lobes, we should certainly expect to find that modification which is characteristic of the shell-bearing Phyllopods, but we are not at liberty to assume any close analogy, since different families of animals, however nearly allied, do not exhibit the same arrangements in detail, each particular organ not being similar in allied groups, but such groups rather exhibiting general relations, and often showing marked differences in particular points of structure. This law is illustrated in other ways in the case of the Trilobites, and we cannot doubt its universality; so that in giving a certain form to the feet in the restored figure (See Plate VI, Figs 7, 8), I have done so rather intending to indicate what they may have resembled, than with any idea of assuming their actual form. I merely assert that these organs were soft, membranous, and fringed, adapted for locomotion in water, placed on the abdominal portion of the body, and extending sidewise beneath the lateral lobes of the rings, as shown in the ideal transverse section. (Fig. 7.) These feet were also indented, and thus divided into several lobes at the open lower side, and each separate lobe was furnished at the margin with small bristles serving as fins. The last and external lobe (*c*) was probably longer, smaller, and more moveable, and reached to the termination of the protecting shell-lobe (*a*), bearing a bladder-shaped gill (*b*) on the inner side. The protecting lobes of the feet of the *Phyllopoda* were probably entirely absent in the case of the Trilobites, the hard shell affording sufficient protection, and the space beneath its lateral lobes not being large. How far along the body the feet extended is a matter that I must leave undetermined, but I am inclined to suppose that they may have reached the abdomen, as in *Apus*, since the caudal shield frequently exhibits the same impressions as the lateral lobes of the thorax, and these impressions were no doubt connected with the existence of feet. The oblique transverse furrow at each of the lateral lobes indicates perhaps that the foot was situated, or perhaps partly attached behind it, at the broader part, which issues from the ring of the axis, whilst the smaller anterior part of each lobe was adapted for articulation with the preceding one, at least in those genera possessing the capacity of doubling themselves into a ball, where there seems to be a deeper insertion at the spot where the lateral lobe turns itself downwards, in proportion as the facility the animal had of doubling itself up is greater. Since also the anterior oblique surface of the lateral lobes, which was pushed beneath during the operation of doubling up, never reaches further than to this apparent point of articulation, this circumstance renders still more probable the supposition of a more intimate connexion of the lateral lobes with one another, from the axis up to this very spot.

It may also perhaps be a subject of investigation, whether the feet of Trilobites resembled each other in shape and size, as in *Branchipus*, or whether the anterior were different from the rest, and the posterior ones became gradually smaller, as in *Apus*. Such questions are no doubt difficult to answer, but still there are certain circumstances which may help us in coming to a probable conclusion on the subject.

And first of all I do not imagine that any of those Trilobites capable of rolling themselves into a ball possessed the peculiar swimming apparatus observable in the first pair of feet in *Apus*; since this apparatus, consisting of long appendages projecting far beyond the margin of the integuments, would seem to require special organs of retraction to admit of being folded and concealed quickly and safely while the animal was rolling itself up at the moment of danger, and this difficulty would exist even if they were not so

long as in *Apus*. I presume, therefore, that in this respect the Trilobites resembled *Branchipus* rather than *Apus*; or that those at least which possessed the power of doubling themselves up had the anterior pair of extremities perfectly similar to the rest. And this, indeed, appears also to have been the case, from the equality of the thoracic rings observable in *Branchipus* and in many Trilobites capable of doubling themselves up, this equality appearing to correspond with a similar equality in the dimensions of the extremities attached to them. Since also in *Branchipus* there are no feet attached to the abdominal rings, in this respect also we might expect a correspondence with the group of Trilobites now under consideration, and this seems the more probable in the case of those genera amongst them which have a short axis, and no lateral ribs on the caudal shield (*Asaphus, Illænus, Nileus, Ampyx*). For similar reasons, however, I assume that this structure obtained also in the other genera (*Calymene, Homalonotus, Phacops*) capable of doubling themselves up, and also in others (*Oggygiæ, Odontopleuridæ*) not having this power, but characterized by equal thoracic rings. In these, however, the existence of abdominal feet may perhaps be inferred from the lateral furrows of the caudal shield.

On the other hand, it appears probable, from the decrease of size observable in comparing the anterior with the posterior portion of the body, that in the other groups (the *Olenidæ* and *Campylopleura*), in which the animal was not able to roll itself into a ball, the extremities were not all of equal size, but diminished towards the posterior part of the body, with the diminution in the size of the rings; while the thoracic rings passed gradually into abdominal rings. This is the case in *Apus* and *Limnadia*, where the rings increase a little at first, but then diminish in size from the centre of the thorax, and, becoming progressively smaller, pass into the rings of the abdomen. From the analogy here presented, we might also expect that the first pair of feet from the thoracic feet of the *Olenidæ* and *Campylopleura* were provided with filaments instead of fins, or that at least the antennæ of the head were larger and more like those of *Limnadia*, while in other Trilobites they must certainly have been short and small; and they could not have projected beyond the margin of the cephalic shield, for the same reason which prevented the development of the lobes of the first pair of feet into filaments.

SECTION XXII.

Convinced that the reasons already offered will be deemed sufficiently conclusive to satisfy the unprejudiced reader, I venture now to offer the following deductions and general conclusions:

The TRILOBITES *were a peculiar family of* CRUSTACEA, *nearly allied to the existing* PHYLLOPODA, *approaching this latter family most nearly in its genus* BRANCHIPUS, *and forming a link connecting the* PHYLLOPODA *with the* PÆCILOPODA.

In order, however, to estimate fairly the affinity of the Trilobites with the *Phyllopoda*, we must not lose sight of the important fact, that the Trilobites differ not only from the *Phyllopoda*, but from all other existing families of Crustacea in the varying numerical proportion of their thoracic rings; a peculiarity neither exhibited at present as a characteristic of any natural family among the Crustacea, nor in any of the heterogeneous Articulata.

This peculiarity occurs, it is true, among the *Aspidostraca* (a group of the second great division of the Crustaceans), but only in a modified form, the difference in the numerical proportion being always reducible to one fundamental number. This law is apparently not observed in the case of the Trilobites.

It would seem then that the relation existing between the Trilobites and the existing Crustacea is one rather of analogy than affinity, so that the whole group may be considered as a separate division, corresponding with the *Aspidostraca* in the formal variation presented from the typical character, but not to be looked on as a nearly allied or similar group to this or to other tribes.

Putting out of the question the important difference exhibited in the numerical proportion of the thoracic rings just alluded to, this analogy to the *Aspidostraca* might certainly have been considered as very close—all the other relations of organization, so far as they can be traced, corresponding very accurately—if it were not for the structure of the extremities. These, indeed, which are hard, horny, and articulated in a subdivision of the present *Aspidostraca*, were probably entirely absent in this form in Trilobites; but in other respects all the typical characters of the two groups will be found to correspond.

The present, however, appears to be the proper place to institute a still further investigation into this subject, which may serve as an additional illustration.

SECTION XXIII.

It follows as a matter of necessity that the Trilobites, belonging as they did to the great natural division of articulated animals, must have been subjected to a periodical growth, during which their horny or stony cases were thrown off and exchanged for new ones. This has been already alluded to by Wahlenberg, who has also suggested that some supposed new species may have been founded upon these cast shells. I am not, indeed, inclined to agree to the probability of this assumption; but in order to illustrate my own views on the subject, it will be necessary first to describe the process of exuviation and development of the recent *Phyllopoda*.

SECTION XXIV.

All *Phyllopoda* are subjected to a true metamorphosis, and that a progressive one. They leave the egg as unarticulated pyriform animals, and at the anterior thicker extremity of this pyriform body we perceive one simple eye, two pairs of unequal oar-shaped feet, rudimentary antennæ, and an organ of locomotion, in addition to the two pairs of feet which subsequently converted itself into the real branchial apparatus.* The young animals are always quite naked and destitute of shells, whether the parents possess shells or not. If the

* Fig. 11, in Table VI, represents the young of a *Branchipus* immediately after its emergence from the egg; Fig. 13, the young of *Apus* after the first moult—*a* indicates the small antennæ, *b* the large ones, *c* the foot of the branchial apparatus, *d* the rudiments of the subsequent feet.

latter be the case, the young never receive a protecting covering; if, however, the parents have shells, then the first traces of it are seen immediately after the first moult, in the form of a membranous fold, which issues from the neck, and which at once covers one half of the body. The young animal, after this period, has become considerably larger, and its body has become thicker and exhibits lateral notches behind the third organ of locomotion, from which the feet gradually develop themselves. The little animal still retains its first three organs of locomotion in an unchanged form as long as the feet remain imperfect; as soon, however, as the feet (which grow laterally from the body) have attained their relative development, in proportion to the dimensions of the animal, the former organs of locomotion begin to diminish, and are gradually metamorphosed into the form exhibited in the full grown animal, which is frequently very rudimentary. It can then be distinctly seen that they are the true tentacula of the developed animal, and that according to their size in the subsequent stages of existence they are more or less diminished or modified. The formation of the eye progresses equally with this metamorphosis. At first it is a simple small point or dot, and first appears about the time when the anterior half of the thoracic feet have formed themselves into isolated organs; but, besides this little dot, there are a couple of other dark spots in the head, which simultaneously and gradually with the other organs form themselves into compound eyes. A very short period of time is required for the formal development of the rest of the animal, for the subsequent structures are already conveniently isolated and perfectly formed when the young animal has scarcely reached the hundredth part of the dimensions it is afterwards to attain. From this time forward, therefore, it advances regularly in its growth, and casts its membranes from time to time, at longer or shorter intervals, as the rapidity of its growth may demand. The cast-off membranes are split along the whole length of the back, and the animal draws forth all parts from this opening gradually in such a manner that even the smallest hair remains affixed to the old membrane and forms itself anew on the new membrane. The cast-off membrane, however, consists only of the epithelium, never of the real cutis, and it is therefore very thin and delicate. The Trilobite remains which are said to have been produced from such exuviæ are thus probably mere impressions, and do not exhibit remains of the shell itself, since distinct evidence of its having been cast off would have been preserved in a longitudinal section along the centre of the back, and such a section not having been yet observed in any Trilobite, I consider the opinion expressed by Wahlenberg, that in many supposed Trilobite shells we have only the cast-off membranes before us, to be incorrect.

It may still be thought probable, however, from the nature of the metamorphosis of the *Phyllopoda*, that Trilobites experienced a similar change, nor do I at all question the possibility of such a view being correct. On the contrary, I am inclined to recognize the vestiges of such early stages of the animal's growth in the obscure shields which have been supposed the types of new genera, under the names *Agnostus* and *Battus*; for, on carefully examining specimens of the former, we find not only a singular variation in size, occurring as they do from the dimensions of a mustard seed to that of a pea, but also a perceptible difference in the form of their constituent parts, and I think I can distinguish four different forms, which may be brought under two groups. Before, however, explaining these, I shall describe the *Agnostus* shield in general, referring for illustration to the representations.

SECTION XXV.

On the other hand, however, there arises a very natural suggestion, that the Trilobites may have undergone a metamorphosis similar to that described as characterizing the *Phyllopoda*. I by no means question the great probability of such a modification, but there is as yet no distinct evidence in support of it, for up to the present time no one has been fortunate enough to discover a specimen in the young state, offering any distinct indication of gradual development or metamorphosis. My original notion, that the so called genus, *Battus*, was founded on the shields of the heads of young Trilobites, has since been disproved by Dr. Beyrich, who has shown, on the other hand, the probability that these shields belong to a particular genus of Trilobites, the one form of them covering the head, and the other the tail, while the two were connected by an articulated body formed of two rings. This genus we shall afterwards describe more in detail in its proper place.

SECTION XXVI.

Although, according to these observations, the development of the Trilobites has not yet been proved identical with that of the *Phyllopoda*, there can still be hardly a doubt that there exists a completely analogous organization in the two groups, and a circumstance which has hitherto been overlooked seems to render this analogy still more probable. The three principal stages of modification of the fundamental type, which at present exist in the three families of the *Phyllopoda* above described, likewise seem to be presented in the case of the Trilobites. In the former group we observed that there are—(1) Naked *Phyllopoda* (*Branchipus*); (2) *Phyllopoda* with a simple horizontal shield (*Apus*); and (3) *Phyllopoda* with a bivalve, perpendicular shield (*Limnadia*). Precisely the same differences of structure are also found among the Crustacea that lived at the period of the Trilobites, and thus the analogy of those early types with their present representatives, the *Phyllopoda*, is confirmed in a very singular manner.

Besides the true Trilobites, of which the broad, flat, perpendicular shield leaves no doubt that we must recognize it the analogue of the simple perpendicular shelled *Apus*, we find also in the Palæozoic strata the remains of two other crustaceous animals, one of which (*Cytherina*) was covered with a bivalve shell, offering a perfect resemblance to that of *Estheria*, while the other (*Eurypterus*) was entirely without any shelly covering, and seems to have been analogous to *Branchipus*. Of *Cytherina* nothing has been preserved but the shell, and, according to Hisinger's figure,* it so perfectly corresponds in structure with *Estheria*,† that it is scarcely necessary to say another word respecting the relations of affinity of the

* Lethæa Succica.

† See Strauss, in 'Museum Senkenbergianum,' tom. ii, p. 119, Table VII, and the still better figure given by Joly, in the 'Annales des Sciences Natur.' Nouv. Sér. tom. xvii, p. 293, Pl. 7-9. 1842.

two forms. It must be evident to every naturalist, that to recognize the analogues of the genera *Cypris* or *Cythere* in these shells, is far less probable than the affinity now suggested. The more recent forms obtained from the fresh-water limestones of the Weald, and described as *Cypris faba*, may, however, have really belonged to this genus.

To prove by *a priori* reasoning that *Eurypterus* was a shell-less Trilobite, just as *Branchipus* is a shell-less Phyllopod, may appear difficult; yet even in this view I think I am fully justified. The figures which Harlan has recently given us in his 'Medical and Physical Researches,' p. 298, leave no doubt in my mind on the subject; and it is from the study of these figures, and from the similar one given by G. Fischer (Notice sur l'Eurypterus de Podolie, Moscow, 1839), that I have derived my conclusions. The animal, according to the description, possessed a head which appears broader than the glabella of the Trilobites, because it was softer and compressed, but otherwise corresponds with it in form. We recognize in it two large lunate eyes, in which the black pigment of the centre may be very well distinguished from the glassy spheres and lenses extended above it, as the figures of Harlan distinctly show. These eyes were also unquestionably compound, and had a simple, smooth, horny membrane. Three pair of organs seem to be affixed to the lower surface of this head; two of them being somewhat small, and situated at the anterior margin, and the articulation of which is no longer recognizable, although the long bristles with which they were furnished appear quite distinct. I take these for the antennæ, and suppose them to correspond with the first two organs of locomotion of the *Phyllopoda*. The third pair of organs of locomotion of the head were longer than the two others, thicker, more distinctly articulated, free from bristles, but furnished at the end with hooks; they probably formed the accessory pair attached to and forming part of the mouth, and were useful to the animal when seizing its prey. It decidedly appears, from Figure 2 of Harlan's Plate, that there followed behind these three pair, and at the first thoracic ring, a couple of large, broad, articulated, but soft fin-feet, the number of joints of which appears to have been five. These also undoubtedly bore bristles at their margin, but their delicate nature prevented the impression from being retained. Together with this first thoracic ring, I recognize in Harlan's figure (Fig. 1) twelve rings, although in Fig. 2 there are only ten distinctly to be seen, but in this case the extremity of the abdomen is injured; Fischer has represented fourteen rings, and a still further number is indicated in his figure. This impression, indeed, seems generally to point to specific differences, on account of the sharp lateral prongs of the rings of the body; but we might also take these lateral lobes for the extreme ends of the fin-feet, and assume at the same time that they were much smaller than the first pair, according to the analogy of *Apus* (Table VI, Fig. 1). I am myself decidedly of this opinion, and consider that it is not feet that are visible in the figures of Harlan and of Dekay, the animal having been too much compressed by the petrified mass during its inclosure, to admit the possibility of the extreme ends of the feet projecting in this manner. The softer abdominal side of the body, together with the feet, may, however, have been already cast off in these very specimens, and this is another and also a very probable conjecture. I believe in other respects that of the whole number of the rings we must reckon nine as belonging to the real thorax, the remainder being abdominal. The great diminution of the body from the ninth ring, and the equal breadth of the succeeding rings are reasons in favour of this conjecture, and the deviating formation of these first rings in

Fischer's figure may be considered as another. The first six rings certainly here appear to be much more peculiar than the three next succeeding ones; but, considering the other points of identity in structure between this species and the North American one, we are probably justified in assuming that they must have had an equal numerical proportion, so far as the thorax is concerned. According to this view three, or perhaps six rings would come to the abdomen, and this proportion would correspond with the prevalent type both of the Trilobites and *Phyllopoda*. A separation of both divisions of the body in six and six, or in six and nine rings, is, however, also conceivable, and indeed easily to be accounted for by the analogy of *Apus* and also of the species of *Pharops* referred to the second division.

SECTION XXVII.

Having adduced so many analogies and homologies of structure between the Trilobites and the *Phyllopods*, we may be permitted to assume some similarity also in the habits of the two groups, and I now propose to add some remarks on this subject.

The *Phyllopoda* live in stagnant fresh waters, especially in ditches, pools, or puddles, which are very rapidly produced after rain in the early part of the year, and last only till the middle of the summer, when they become dried up. During this period the animals of the tribe we are describing are usually seen in numerous companies swimming about in the water at various depths, the species of *Branchipus* being most frequently close beneath the surface of the water. In swimming they turn their back downwards, their abdomen being upwards, so that the feet touch the surface of the water, and accordingly *Branchipus*, has its eyes in the position in which I have represented it in Table VI, Fig. 3, and not proceeding from the head rectangularly. This position of the eyes enables the animal to look both upwards and downwards. *Apus*, on the other hand, which has immoveable eyes, can only look downwards while swimming on its back, and it must turn itself if it wishes to look upwards. But this is quite natural, since in each case the animal, when in its usual position, and close beneath the surface of the water, can only have its enemies below, and therefore only needs to be secured against surprise in that direction. These creatures are, however, not much exposed to attack. Their prey, which consists of other little animals living in the water, they obtain during their constant swimming motion, and it is brought to the mouth by the motion of the water. Owing to this, the region and cavity of the mouth in many of these animals, when preserved in spirit of wine, are frequently entirely covered or filled up with extraneous substances. The *Phyllopoda* are never at rest, partially because they are entirely deficient in organs by which they could keep firm hold of anything, partially also because their motion of swimming produces at the same time the motion of the respiratory organs, which being independent of the will of the animal does not cease. I have not yet had an opportunity of observing *Limnadia* and *Estheria* in a living state, but both genera undoubtedly exist in the same manner; I am not, however, aware whether they swim on their back. Considering the affinities of the Trilobites with the *Phyllopoda*, I cannot doubt for a moment that their habits during life and their mode of existence were similar, and I therefore conclude—

1. That these animals moved only by swimming, that they remained close beneath the surface of the water, and that they certainly did not creep about at the bottom, as Mr. Klöden supposed.*

2. That they swam in an inverted position, the belly upwards, the back downwards, and that they made use of their power of rolling themselves into a ball as a defence against attacks from above.

3. That they lived on smaller water-animals, and in the absence of such, on the spawn of allied species.

4. That they most probably did not inhabit the open sea, but the vicinities of coasts, in shallow water, and that they here lived gregariously in vast numbers, chiefly of one species.

5. That the number of species could never have been very great. This is indeed proved by the mode of their appearance in the fossil state, inasmuch as scarcely more than six or eight species have been found together anywhere in one stratum.

6. Although the number of species has not been large, the number of individuals was very great indeed; a fact likewise observed in the living *Phyllopoda*, of which we as yet scarcely know a dozen species, although these are grouped into about six different genera.

7. The great differences existing in the dimensions of the present *Phyllopoda* according to their age, justify us in expecting such differences also among the Trilobites; and very large individuals of the latter, therefore, do not indicate a separate species, unless other differences are presented.

* See 'Verst. d. Mark Brandenburg,' von H. Klöden, p. 104.

CHAPTER III.

SYSTEMATIC ARRANGEMENT OF THE SPECIES.

The arrangement of Trilobites, and their position amongst the Crustacea, now no longer offers any difficulties, and they may be most conveniently described in the following manner.

If, as the observations already offered would seem to demand, we arrange the genera *Cytherina* and *Eurypterus* with the Trilobites in a single division, we have a group parallel to the existing *Phyllopoda*; to designate which we may employ Dalman's name *Palæadæ*,* and which may thus be described.

The Palæadæ are crustaceous Articulata, belonging to the second order of the class Crustacea (divided into *Ostracodermata*, *Aspidostraca*, and *Entomostraca*), characterized by the possession of two large compound eyes, by the absence of simple secondary eyes, and by having short undeveloped feelers, and soft leaf-formed feet, bearing gills. By these characters they are immediately related to the *Phyllopoda*, and might perhaps even be united with the latter in one tribe. Their principal difference would then consist in the absence of the constant numerical proportion of eleven rings of the thorax, common to all the *Phyllopoda*, which must be expressed by the formula of $4 \times 3—1$. Instead of this, the *Palæadæ* exhibit fluctuating numerical proportions in the parts of the thorax, respecting the reduction of which to a constant formula, nothing certain can be said; because we neither know the number of the accessory parts of the mouth, nor the position of the sexual openings. These animals underwent a progressive metamorphosis, they moved by swimming, probably with their backs downwards, and they inhabited the ocean, living chiefly in shallow water. The whole group is divided into three families, which are characterized according to the nature of the shelly covering.

First Family—EURYPTERIDÆ.

In these there is no shell. The head, whose position is very distinct, bears two pair of setaceous feelers, and one pair of accessory parts of the mouth. There are probably nine (?) rings in the thorax, the first of which bears a pair of very large rudder-shaped feet.

* See the article written by me on the *Entomostraca*, in Ersch and Gruber's Encyclopædia, sect. i, vol. xxxv, p. 134. I here first explained the relations of the *Palæadæ* with the existing *Phyllopoda*.

furnished with five joints; and the succeeding rings seem to have borne similar leaf-like feet of an equal size. The abdomen consisted of three or six rings, and was terminated by a pair of rudder-fins (?).

There is only one genus belonging to this family, and of this there seem to be three species.

Eurypterus, Dékay.

1. *E. remipes:* Somewhat slender, the terminal joint of the large fin-feet equal in length to the preceding. Length of body 3½″, breadth at the upper part 1½″.

Reference.—Dékay, *Annals of the Lyceum of Nat. Hist. of New York*, i, 12, 291, Plate XIV; and 375, Plate XXIX (1826). Froriep's *Notiz.* 1827, xviii, 1-3. Holl, *Petref.* 155. Bronn, *Lethæa*, i, 109, Table IX, Fig. 1. Harlan, *Med. and Phys. Research.* 297. *c. fig.* Mitchell, *Am. Month. Magaz.* iii, 291.

Locality.—Slate rocks of Westmoreland, Oneida, and New York.

2. *E. lacustris:* Broader than the former species, and the terminal joints of the large rudder-feet much smaller. Length of body almost 5″, breadth 2½″.

Ref.—Harlan, as above, 298. *c. fig.*

Loc.—The grauwacke rocks at Williamsville, seven miles from Buffalo, U. S.

3. *E. tetragonophthalmus:* Eyes placed at a greater distance from one another, quadrangular (?), the whole of the structure very slender, especially that of the abdomen, the joints probably acutely angled. Length nearly two inches, breadth ¾.

Ref.—G. Fischer, *Bullet. de la Soc. Imp. d'Hist. Natur. de Moscou*, 1839, ii, 127, Plate VII, Fig. 1; and his *Notice sur l'Eurypt. de Podolie, etc.*, Moscow, 1839, 4.

Loc.—The transition limestone or grauwacke sandstone of Podolia, at the village of Zvilevy, twenty wersts to the south of Kamenetz.

It is probable that the fossil described by Scouler under the name of *Eidotea*, may belong to a species of this genus. Fragments of it only are known, and these correspond with the head and the commencement of the thorax of *Eurypterus*, but certainly belong to a different species. See the following works respecting it: Cheek's *Edinb. Journ. of Nat. Science*, 1831, June, N. S. iii, 352, Plate VII. Leonhard and Bronn's *Jahrbuch*, 1832, 251. Bronn, *Lethæa*, i, 109, 98, Table IX, Fig. 2; and Hibbert, *Transact. Roy. Soc. of Edinb.* 1834. This latter reference I have not had the opportunity of verifying.

Second Family—CYTHERINIDÆ.

These animals were contained in bivalve, bean-shaped shells, which are the only parts preserved. They are more or less pointed towards the external wider margin; at the straight or dorsal margin they are rather thickened. They vary in size from ½″ to ¾″, or even (though rarely) to 1″.

The only genus, *Cytherina*, which belongs to this family requires as yet a more accurate study, as there seem to be several species which have hitherto been confounded with one another. The specimens from the mountain limestone are probably, however, the only true representatives of the genus, and the species referred to *Cypris*, and found in the wealden, cretaceous, and tertiary formations, probably belong to a different and peculiar group. For the present we may consider as belonging to it—

1. *C. baltica*; Hisinger, *Leth. suecica*, 10, Table I, Fig. 2, and Table XXX, Fig. 1.
2. *C. phaseolus*; Hisinger, ibid. Table I, Fig. 1, and the *Anteckning i Phys. och. Geogn.* of the same author, V, Table 8, Fig. 3. Klöden's *Verst. d. Mark Brandenburg*, 102, Table I, Fig. 10-11.

Third Family—TRILOBITÆ.

The body covered by an affixed shell, which consists of as many rings as there are joints of the thorax (?); the head and the abdomen each similarly included in a large united shield, which, like the rings of the shell of the body, possesses a broad border that freely projects at the sides. The large eyes are situated in the lateral portions of the cephalic shield, remote from the true head. A peculiar suture passes through the cephalic shield, and divides it into two, three, or four special parts. The numerous members of this family, which have been already particularly described in the first chapter, admit of a further division into natural genera, the most suitable classification of which may perhaps be the following:

1. *Trilobites incapable of rolling themselves up.* The Trilobites of this division appear to be decidedly of more ancient geological date than those of the following divisions, and are principally found in the lowest Silurian rocks, but are there accompanied by some species of the other group. They are easily recognized by the structure of the lateral lobes of the body, which is such that throughout its length each preserves the same breadth, and never diminishes on the upper and external side towards the margin, a peculiarity observable in the members of the second group. The lateral lobes of these Trilobites, therefore, represent narrow parallel courses, which are usually divided in a diagonal direction by a transverse furrow. On a more accurate examination, however, we find that two different types predominate in their configuration, which present new differences, the details of which we need not dwell upon in this general description. The species of this first principal group are further distinguished by the smallness of their eyes, which are depressed, and have a more elongated form than the eyes of other Trilobites. Only the inner surface of the shell is known, the upper surface being absent in almost all the specimens hitherto found, excepting those belonging to the genera *Odontoplenra*, *Brontes*, and *Harpes*. This is especially the case in those found in grauwacke, clayslate, and alum-slate. As already mentioned, this group is divided into two sections, according to the characters of the lateral lobes.

GROUP THE FIRST.

The lateral lobes of the rings of the body are situated in the same plane, and do not curve or bend downwards, but terminate towards the posterior part in a more or less prominent point, sometimes very long, which forms a somewhat obtuse angle in its principal direction with the direction of the lobe.

Of this group there are further subdivisions, which may readily be distinguished from one another, being founded on the presence or absence of a large caudal shield.

Division A.

Trilobites *with a simple, large, caudal shield (not much smaller than the cephalic shield), the axis of which is many-jointed, and equals, or even exceeds, the length of the body.* Ogygiidæ. To this group belong two genera, *Trinucleus* (with six rings) and *Ogygia* (with eight rings).

Genus 1.—Trinucleus, Murchison (Cryptolithus, Green).

Cephalic shield almost semicircular, with a margin which is dilated all round and punctated, and with posterior angles terminating in long spines; the central glabella very convex, much contracted at its posterior part before the margin; without lateral lobes or furrows.

The eyes and the facial suture I have not yet myself been able to examine.* The body is short, the six rings narrow, scarcely half as broad as the lateral lobes, the latter with a distinct diagonal furrow, and with a fine short angle.

Caudal shield triangular; the axis articulated in six or more jointed, the sides without radial furrows; the margin reflexed and acutely angular.

Locality.—In the lower and middle Silurian strata.

Remark.—Several species are known, from the lower Silurian strata of England, North America, Sweden, and Bohemia. Some authors enumerate only five body-rings, probably by mistake, or in consequence of the defective preservation of the individual.

1. *T. Caractaci:* Limbo scuti cephalici orbiculari, concentrice punctato; angulis posticis subrectis, longe spinosis; caudæ basi annulata, apice scuti acuto. Long. ¾-1¼″. Plate I, Fig. 1.

Ref.—*T. Caractaci*, Murchison, *Sil. Syst.* pt. ii, p. 659, Plate XXIII, Fig. 1, *a, b, c, d, e.* Brongn. *Crust. foss.* Plate IV, Figs. 6, 7, A, B, C, p. 145. Lhwyd, *Phil. Trans.* vol. xx, p. 243, Plate, Fig. 8. Bigsby, *Annals of the Lyc. of Nat. Hist. of New York*, i, 214, Plate XV, Fig. 1. Emmr. *Diss.* 51. 6. Milne Edw. *Crust.* iii, 331. 1. Portlock, *Report*, 262, Plate I, B. Fig. 3-7.

Cephalic shield nearly semicircular, broader than long, the enlarged margin covered with five to six concentrical rows of little pits, from which rise small wart-like prominences; posterior angles oblique and oppressed, each terminating in a long pointed spire as long as

* Dr. Lovèn (Ofvers of Kongl. Vetensk. Ak. Förh. 1845, No. 4) describes the facial suture as running close to the margin of the cephalic shield, turning inwards at the posterior angles, and intersecting the posterior margin of the shield at about the middle. In accordance with this statement, such an arrangement has been indicated in the figure of *Trinucleus Caractaci*.

the body; glabella almost twice as long as broad, anteriorly rather hemispherical, posteriorly contracted, with the vestige of a knob at each side. Six distinct rings of the body, the axis of each scarcely half as broad as the lobes. Caudal shield triangular, with a slightly elevated angle at the exterior margin; its axis only articulated to a little beyond the centre, with six rings, afterwards simple; the lateral lobes furnished with six radiating striæ divided towards the margin.

Remark.—Described from specimens in the Museum at Halle, occurring in a yellowish grauwacke. Found also in the lower Silurian strata of England, North America (Montreal), and Bohemia. (Sternberg, *Verhandl. d. vat. Mus.* 1833, Fig. 2, *b.*)

2. *T. granulatus:* Limbo scuti cephalici orbiculari, punctato; angulis posticis lobatoproductis, breve mucronatis; scuto caudæ subsemicirculato, rhachi tota annulata, annulis sex. Long. $\frac{2}{3}''$.

Ref.—*Ent. granulatus*, Wahl. *n. act. Ups.* VIII, 30. 5, Table II, Fig. 4. *Asaph. gran.* Dalm. *Pal.* 43. 4, Table II, Fig. 6. Brogn. *Cr. f.* 36, Pl. III, Fig. 7. Milne Edw. *Cr.* III, 332. Boeck. *Gaea norv.* 41. *Trinucleus Lloydii*, Murch. *Sil. Syst.* Pt. II, 660, Pl. XXIII, Fig. 4. Emmr. *Diss.* 53. 9. Milne Edw. *l. c.* 4. Loven. *Öfvers K. V. A. Förhandl.* 1845; 109, Tab. II, Fig. 2.

Cephalic shield, like that of the preceding species, but the posterior angles produced into broad, parallel, punctated lobes, which project backwards beyond the rings of the body, and finally terminate in a delicate spine rather shorter than the lobe. Rings of the body not so narrow as in former species, and more than half as broad as the lateral lobes. Caudal shield, a segment of a circle smaller than a semicircle; the axis indistinctly articulated; the sides without ribs.

Occurs in a black limestone belonging to the upper members of the lower Silurian series in Great Britain and Scandinavia.

3. *T. fimbriatus:* Limbo scuti cephalici dilatato, radiatim granulato; angulis posticis irregulariter granulatis, subrectis, mucronatis; cauda tota annulata, annulis 12-13, long. 1″.

Ref.—Murch. *l. c.* Pl. XXIII, Fig. 2. Luid. *Ichnogr.* p. 97, Tab. XXIII. Emmr. *Diss.* 52. 7. Milne Edw. *l. c.* 2. Portlock, *Report, &c.;* 264, Pl. I, B, Figs. 11, 12. Sars, *Isis*, 1835; Tab. VIII, Fig. 4, *d* (certainly not the caudal shield of an *Ampyx*).

Cephalic shield shorter and broader than in the preceding species; the margin furnished anteriorly and at the sides with radiating pores; the posterior angles not contracted, irregularly granulated with pores, with a long, nearly straight, terminal spine. The glabella but little diminished posteriorly, with slight traces of lateral impressions, but little longer than broad. Rings of the body indistinct; body shield oblong-triangular; the whole axis articulated as far as the extremity, long, consisting of thirteen or more rings; the sides with twelve radiating ribs; the margin acutely angled.

Remarks.—1. *T. nudus* (Murch. *l. c.* Fig. 5) I am inclined to consider the same species, with the margin broken off at the cephalic shield. See Emmerich, Fig. 5.*

* Note, by the Editors. *Trinucleus nudus* is really a species of *Ampyx*, as may be seen by consulting the original specimens in the Museum of the Geological Society of London, and still more perfect ones in the collections of the Geological Survey of Great Britain.

2. *Asaphus seticornis* (Hisinger, Leth. Succ., second supplement, Tab. XXXVII, Fig. 2) cannot be identified with *T. fimbriatus*, as figured by Portlock (*l. c.* 263, Pl. I, B, Fig. 8), and Lovèn(*l. c.* 107, Tab. II, Fig. 1); but is a different and highly characteristic species allied by its rounded caudal shield more nearly to *T. granulatus* than *T. fimbriatus*. *A. cyllarus* (Hisinger, *l. c.* Fig. 3) is, according to Lovèn, the same species, the spine of its cephalic shield being broken off.

4. *T. ornatus:* Limbo scuti cephalici antice angusto, extus posticeque lato, sed constricto; angulis posticis acuminatis, longe spinosis.

Tril. ornatus, Sternb. *Verh.* 1833. 53. Fig. 2, *a*. *Trin. radiatus*, Murch. *l. c.* Fig. 3. Emmr. *Diss.* 52. 8. Milne Edw. *l. c.* 3, and 332. Boeck, *Gaea Norw.* 42.

Cephalic shield as short and broad as in the preceding species, but the border at the anterior margin smaller, and the tubercles not radiated, but in (four to five) concentric rows; the sides very much enlarged, with five to six rows of pores, but very much contracted again towards the posterior angle, so that this region of the margin assumes the form of the letter S. The terminal spine is long, slender, and pointed. The glabella is oval, higher, more obtuse at the anterior part, and more globose. We are not yet accurately acquainted with the rings of the body and tail.

Remark.—The statement in Murchison's work, that the enlarged margin in this species has only two rows of tubercles, I must consider incorrect; Count Sternberg describes from four to five. *Trin. asaphoides* (Murch. *l. c.* Fig. 6) is probably a specimen of *T. ornatus*, in which the margin of the cephalic shield is broken away. If this conjecture be correct, the caudal shield would be more shortly triangular, but the axis would likewise be many-jointed, having perhaps from ten to eleven lateral ribs. Possibly, however, the body thus referred to may be referable to the species last described.

N.B. Both the former species and the present occur, but rarely, at Builth in the Llandeilo flags, and in Bohemia. Count Sternberg's specimens were found in a rock very much loaded with pyrites, in the district between Zebrak and Proskales, in Bohemia. Similar fragments have been found in the calcareous conglomerates of Carlshütten and Beraun. These have been figured by Zenker, (Beitr. Table IV, Fig. N, 5); and partly from these, partly from the caudal shields of quite a different species, the author has composed his *Otarion deffractum*. This genus *Otarion* must be banished from the list of Trilobites.

5. *T. tessellatus:* Limbo scuti cephalici parabolico, tesselato-punctato; scuto caudæ triangulari. Long. ½″.

Cryptol. tessell. Green, *Mon.* 73, Fig. 4; and Model, No. 28. Bronn, *Leth.* i, 117, 105, Table IX, Fig. 13. Emmr. *Dissert.* 50. 2. Harlan, *Zool. Res.* 304.

To judge from the impression, and from plaster casts, this species is more oblong and smaller than the others; the form of the cephalic shield more parabolic, the lateral lobes of the rings of the body more arched, the caudal shield trilateral, rather acuminate.

Occurs in a black limestone of Trentonfalls and Glenfalls in New York; also on the Island of Montreal.

Remark.—Neither representation nor description indicate any more definite differences, and I therefore consider the species as uncertain. The same may be said with still greater reason of *T. Bigsbyi* (Geology of the Island of Montreal, in Lyc. of Nat. Hist. of New York, p. 214; and Green, *l. c.*) and *Nuttainia concentrica* Eaton, (Geolog. Text-Book), both of which I consequently pass over.

Genus 2.—Ogygia, Brongn.

Cephalic shield semicircular or parabolic, flat; the glabella moderately convex, contracted towards the posterior part, with three slight lateral impressions; cheek-shields lengthened into a more or less extended posterior angle.

Eyes moderately arched, semicircular, affixed centrally beside the glabella.

Facial suture very distinct, running in an arch towards the left and right, parallel with the anterior margin, between the latter and the glabella; then turning almost at a right angle towards the eye, forming the well-known plate above it; and then with a curve in the shape of the letter **S**, turning towards it parallel to the posterior margin in the principal direction, and terminating there at about three fifths of its extent from the glabella.

Body certainly composed of eight joints,* the joints short, but tolerably broad, yet less by one half than the lateral lobes; the latter straight, flat, bent strongly backwards at their extremities, and pointed.

Caudal shield corresponding with the cephalic shield, its axis as long as the body, many-jointed, its sides furnished with radiating furrows, the interstices of which are again divided by smaller half rays.

Locality.—In the oldest fossiliferous rocks.

Remark.—This genus stands in so remarkable a degree of affinity to the preceding, that the circumstance of its hitherto having frequently been confounded with the perfectly heterogeneous species of *Asaphus* is truly surprising. It is clear that even accurate observers, as Emmerich and Boeck, have not always estimated correctly the zoological position of these fossils.

1. *O. Buchii:* Scuto capitis caudæque semicirculato; illius angulis posticis acuminatis. Long. 3-5″. Table I, Fig. 2.

Lhwyd, *Phil. Tr.* vol. xx, 279, tab. add. Fig. 15. *Icho. Brit.* Ep. i, Table XXII, Fig. 4, (*see* Brünn.) *Tril. dilatatus,* Brünn, *Kjöbenh. Widensk. Selsk. Skrift.* 1781, i, 393, IV. Parkinson, *Org. Rem. etc.,* iii, Pl. XVII, Figs. 13, 15(?). *Is. d.* Dalm. *Palæad.* 67. 8, Tab. III, Fig. 1. Emmr. *Diss.* 28. 5. Sars, *Isis,* 1835, 336, Table VIII, Fig. 5. *Isot. dilat.* Milne Edwards, *Crus.* iii, 302. 9. *Asaph. de Buchii* Brongn. *Cr. f.* 20. 2, Plate II, Fig. 2, A, B, C. Schloth. *Nachtr.* ii, 34. 8. Dalm. *Palæad.* 68. 9. Murch. *Sil. Syst.* ii, 662, Plate XXV, Figs. 2, 3 (young). Emmr. *Diss.* 28. 5. Milne Edw. *Crust.* iii, 309. 5.

Cephalic shield nearly semicircular, but the longitudinal radius a little shorter than the transverse, furnished at each side with three slight transverse impressions, by which two anterior smaller lateral lobes, and a third posterior broader lateral lobe are indistinctly bounded; the posterior margin is rather distinctly turned up.

Eyes not large, semicircular, corresponding in their position to the two anterior smaller lobes of the glabella. Cheek-shield with a concentric canal-like groove towards the exterior margin, and with a strongly prominent posterior angle, which in smaller specimens reaches

* Quenstedt defends the seven-jointed figures, which were represented from defective specimens; but all the well-preserved specimens that I have seen have had eight rings.

to the third, in larger to the sixth abdominal ring. Body distinctly furnished with eight joints, sometimes owing to the dislocation of two successive rings appearing to be limited to seven (see Remark 2); the rings narrower than the half-lateral lobes, moderately arched; the lateral lobes quite flat, at the end arcuated, curved towards the posterior part, with a strong diagonal furrow, which, however, does not quite reach to the terminating angle. Caudal shield formed like the cephalic shield, but its longitudinal radius larger than the transverse, therefore approximating to the parabolic form; the axis gradually reduced towards the posterior part, rounded off at the end, distinctly articulated, the number of rings in it different according to age (usually thirteen), with a rather longer terminal joint; in younger specimens the number is eleven, in older ones as many as seventeen; the rays beside the axis on the shield usually fewer by about two than the number of joints of the axis; thus, for example, when the number of joints is thirteen, exhibiting eleven rays, with slight traces of a twelfth, besides the two end joints, which are also indistinctly separated; the intervals between the rays again divided by an oblique diagonal furrow, similar to the lateral lobes of the rings of the body.

Remarks.—1. *Asaph. dilatatus* and *A. de Buchii* of authors are probably the same species. The figure in Dalman's work is drawn from a cast, and owing to this circumstance is very indistinct, so that I have preferred the latter name, the species having been first represented distinctly under that. Parkinson's, Brongniart's, and Murchison's distinct figures leave no doubt as to the identity of the species. Lhwyd's figure in the 'Philosophical Transactions' also represents this species tolerably well, for which reason it has been quoted by Brunnich from the 'Ichnographia Britannica.' Individuals vary very much in point of size; I have a caudal shield before me from the collection at Halle (No. 639), which is scarcely so large as a sixpence, having eleven joints in the axis, a pretty long undivided terminal joint, and ten rays. The number increases by the progressive division of this longer terminal joint with increasing age. Another specimen of the same rock (a blackish-gray grauwacke, locality unknown) was figured by me, and compared with perfect specimens in the Berlin Museum (Nos. 9.8 and 9).

2. Quenstedt adheres to the view that these Trilobites are seven-jointed, and founds his opinion on the figures given by Dalman and Brongniart (2, A), as well as on original specimens. There are certainly two well-preserved fragments in the Museum at Berlin (Nos. 9.1, and 9.5), with only seven distinct joints; but there are also others, equally distinct, with eight joints (Nos. 9.8, and 9.9); and the former number can therefore only be owing to a dislocation of two rings one under another. Considering that the impressions are merely those of shells, such a dislocation is very conceivable, and the more readily so, the less perfectly the shell had been preserved. The same remarks hold good with regard to the other species.

2. *O. Guettardi:* Scuto capitis caudaeque parabolico; illius angulis posticis longissime acuminatis. Long. 3-6 inch, Table 1, Fig. 3.

Brogn. *Cr. foss.* 28. 1, Plate III, Fig. 1, A, B. Bronn, *Leth.* 1. 119, Table IX, Fig. 19. Buckland, *Bridg. Tr.* Plate XLVI, Fig. 9. Milne Edw. *Crust.* iii, 337. 1. Dalm. *Palaad.* 72. 1. Emmr. *Diss.* 27. 1. *Tril. Guett.* Schloth. *Petif. Nachtr.* ii, 93, and 35. 13. *Ogygia Murchisoni*, Murch. *Sil. Syst.* 664, Plate XXV, Fig. 3, *a* (the lower figure *b* does not belong to *Ogygia*, but to an *Asaphus*). Milne Edw. *l. c.* 338. 3.

Cephalic shield oblong parabolic, rather pointed; the glabella, as far as it can be recognized, formed as in the preceding species; the eyes oblong elliptical; the posterior angles of the cheek-shield as long as all the rings of the body together, or even longer. Eight body rings, their transverse diameter larger than half the breadth of the lateral lobes,

both of which are relatively longer than in the preceding species. Caudal shield oblong parabolic, rather pointed, with a broad axis, which reaches to only three fourths of the length of the shield, and consists of nine rings; the lateral parts furnished with eight radiating furrows.

Occurs in the blackish-gray clayslate of Angers, in specimens in the Berlin Museum (No. 10. 1).

Remarks.—1. There is no figure of this species in Guettard's 'Treatise on the Slate of Angers' (Mém. de l'Acad. de Scienc., 1757, p. 82), or at the most it is only the figure marked 3, in Table VII, (V), that could be considered as such.

2. Murchison describes several Trilobites in his work, which have been taken for *Oggygia* by other authors, but which do not belong to this genus. *Asaphus corndensis* (663, Pl. XXV, Fig. 4) certainly approximates in many respects to *O. Buchii*, but is probably a genuine *Asaphus*; at least, this is the case if the lateral lobes of the rings of the body have been correctly represented. *A. duplicatus*, (ibid. Fig. 8,) on the other hand, is probably only a flattened caudal shield of *Oggygia Buchii*, in its young state. The figures of *Asaph. tyrannus* (662, Pl. XXIV and XXV, Fig. 1) do not belong to *Oggygia*, but are also to be referred to *Asaphus*.

3. *Oggygia Desmaresti*, Brongn. *l. c.* 28. 2, Pl. III, Fig. 1; Schloth. *Nachtr.* 23. 2, and 35. 14; Dalm. *Palæad.* 72. 2; Milne Edw. *Crust.* 338. 2; Emmr. *Diss.* 27. 2. The impression of a fragment from the lower side presents too few characters to enable one to found a separate species. The specimen perhaps only belonged to a very large specimen of the *Oggygia Buchii*, the rings of which are partially pushed one above another, and for this reason appear small. It certainly belongs to *Oggygia*. Guettard's figures, which are quoted by Milne Edwards, relate to quite a different species, namely, my *Illænus giganteus*.

Division B.

Trilobites having a simple, though tolerably large caudal shield, the axis of which consists of but few joints, and is always shorter than the body.

The genera belonging to this division may be divided, according to the number of body rings, into eight jointed and ten jointed.

First Subdivision (a)

Eight-jointed Trilobites with a short articulated caudal axis, incapable of rolling themselves up.—Odontopleurid.e.

Genus 3.—Odontopleura, Emmr. (Acidaspis, Murch.; Ceraurus, Locke).

This remarkable genus is closely allied in habit to the preceding, and is highly interesting in a zoological point of view, because the two species are commonly distinguished from one another in the same manner as the species of the preceding genus.

The cephalic shield is subsemicircular, the longitudinal radius being much shorter than the other: the moderately convex glabella is undivided in its length, contracted towards the posterior part, and furnished with a strong articulating varix; it enlarges laterally, and at this point has three other little knobs beside it in two rows.

The facial suture resembles that of *Oggygia*, forming at the anterior part an arch before the glabella, then extending inwards to the eye; thence turning to the posterior margin, and penetrating it at about one fourth of the distance from the terminal angle.

The cheek-shields are therefore broad, thickened at the entire exterior margin, prominent, produced beyond the anterior part of the central shield, and furnished with very small eyes above at their highest point, towards the posterior part beside the posterior margin of the outermost lobe of the glabella.

The body-rings (eight in number*) are small, but strongly arched, and the lateral lobes are situated on one plane; each has an elevated transverse ridge, and a long terminal spine directed obliquely and posteriorly.

The caudal shield has a short two-jointed axis, only one elevated lateral rib, but large, strong, marginal spines at the exterior circumference. The surface of the body is regularly covered with tubercles and knobs.

Locality.—In the upper Silurian and Devonian strata of the Eifel, Silesia, and England.

1. *O. ovata*: Corpore ovato, dilatato, undique fimbriatim spinoso; lobis trunci bispinosis, scuto caudae duodecies spinoso. Long. $\frac{3}{4}$ inch. Table II, Fig. 11.

EMMR. *Diss.* 53, adj. tab. Fig. 3; *Battus tuberculatus*, KLÖDEN, *Verst. der Mark Brandenburg*, 112, Plate 1, Fig. 16-23.

This remarkable species occurs in a yellowish, liver-brown limestone, found as a boulder in Silesia by M. Bocksch; the only known specimen was presented to the collection at Berlin by M. Dechen, and I am indebted to the latter gentleman for description and figure.

The circumference is a broad ellipse, the transverse diameter of which is more than two thirds of the longitudinal diameter. The length of the cephalic shield occupies rather more than one sixth of it; the glabella is smooth in the centre, granulated at the sides; the two succeeding smaller tubercles beside it are minutely granulated, the third external one has three more considerable eminences before the region of the eye, and many smaller ones; the cheek-shields are uniformly granulated, and their external reflexed margin is also ornamented with a row of tubercles and spines, which are visible everywhere except in the centre of the anterior extremity. There is a very large tubercle on the centre of the articular fold; beside it at each side a rather smaller one, and surrounding the latter several very small ones. The axis portions of the rings of the body have two rather large tubercles beside the centre, and also two small ones externally at each side. An elevated fold is seen on the lateral lobes, which terminates at the margin in a spine, and which is covered on its surface with seven tubercles, alternately large and small. Towards the anterior as well as the posterior part of this fold we perceive a transverse row of other very small tubercles, and a second smaller row, corresponding with the anterior row, occurs at the margin before the spine. These small spines are all of equal length, but the larger ones become gradually longer towards the posterior part. The caudal shield is rather smaller than the cephalic shield, covered by larger or smaller tubercles, and spiny at the circumference; the spines, of which there are six at each side, are equally long and equally broad; the fold which proceeds from the first ring of the axis becomes bent at the third ring from the centre.

* Emmerich only enumerates seven, but has omitted to notice the fact that both lateral lobes were broken off from the fifth joint, and that thus the true number was not given. Compare his figure and mine.

Remark.—Count Münster's *Trinucleus gibbosus* (*Beitr.* III, 47, Table V, Fig. 27) is probably a fragment of the cephalic shield of this, or of the following species.

2. *O. elliptica*: Elongato elliptica, lobis trunci unispinosis, scuto caudæ decies spinoso. Long. 4". Table I, Fig. 1.

Ref.—*Paradoxides quatuor mucronatus*, Murch. *Sil. Syst.* ii, 658, Plate XIV, Fig. 10. *Acidaspis Brightii*, ibid. Fig. 15 ? *Arges armatus, jun.* Goldf. *Nova acta Ph. Med. Soc. Cæs. Leop. Car. n. c.* vol. xix, P. I, page 355, Table XXXIII, Fig. 1, *d*, *e*.

In a gray limestone of the Eifel, according to a specimen in Sack's collection. Of the cephalic shield there is only a small portion; but this resembles, as far as it goes, the corresponding part of the preceding species; the visible part of the anterior margin, however, is covered with thicker tubercles, and the lobes beside the forehead appear to me to be smaller. The rings of the body (eight) are all present, but only the last two are perfect; on each there are two small lateral tubercles; the lateral lobes are smaller than the double ring, each is furnished with two tubercles, and a long spine which issues from the fold; I did not perceive a second anterior marginal spine. Caudal shield much smaller than in the preceding species, the axis furnished with two rings. The first sends forth a lobe-like swelling to the posterior margin, which terminates at each side in the fourth largest marginal spine; the three preceding ones are successively smaller towards the anterior part, the two most central ones (the fifth of each side) as large as the second.

Remarks.—1. It is quite certain that the figure given by Goldfuss belongs to this species; and is too much unlike his *Arges armatus* to allow of its being considered the same species. Murchison's Fig. 10 likewise undoubtedly represents this species, but it must still remain undecided whether Fig. 15 is the cephalic shield, as Emmerich and I consider it.

2. Several authors have recently described Trilobites, which belong to this group of *Odontopleuræ*. First of all, Mr. Locke (*Sillim. Am. Journ.*) has described a *Ceraurus crassatus*. The fragment of *Arges radiatus*, copied by Goldfuss (*Leonh. and Bronn*), shows a great similarity with the maxillary shield of this species; and it also corresponds with the maxillary shield of another species, *Ceraurus crenatus*, of which Dr. Lovèn (*Öfvers*, &c.) has given an elaborate description. The body in the latter, however, consists of nine rings, which denotes a considerable, and even generic difference. *Ceraurus globiceps* (Portlock, *Geol. Rep. of Londonderry*, &c.) can with less certainty be identified with the genus we are now considering; it seems rather to have affinity with *Ceraurus pleurexanthemus* (Green), a species which is supposed by myself and Dr. Beyrich not to be connected with *Odontopleura*.

Genus 4.—Arges, Goldf.*

As I am not acquainted with this genus from actual investigation, I shall here give an abstract of Goldfuss's description.

Cephalic shield highly arched; at the centre of the glabella there are two very high, reflexed, diverging spines; the sides behind the cheeks are likewise furnished with a spine, the margin is narrow, the posterior part prominent in an angle, rather curved, equal in length to the joints of the body. Below there is a prominent mouth-plate, much turned downwards, which incloses semicircularly the most anterior part of the head behind the

* The name of the genus is not well chosen, as there is already a genus of *Acari* described by G. Fischer under the name of *Argas*; other names of the same author are also subject to similar objections. *Harpes* reminds one too much of *Harpa* or *Harpe*, and Fabricius had already used *Brontes* for a genus of beetles.

margin (the Clypeus). The eyes and facial suture cannot be distinguished. The body is probably furnished with eight joints (only seven rings are distinctly represented in the figure); the rings and the lateral plates are highly arched and broader towards the posterior part; the diagonal diameter of each ring is greater than the width of the lateral lobes; the latter terminate at the margin in a spine; the separate rings are successively broader and larger towards the posterior part.

Caudal shield large, with an almost simple, apparently unarticulated axis, upon which is placed a long spine, bent backwards; the external margin furnished with spines alternately large and small, the sides with indistinct radial folds. The whole surface is finely granulated, there are large tubercles on those parts of the circumference whence spines spring.

Locality.—In the transition limestone of the Eifel.

The only known species is

A. armatus, Goldfuss, *Nova acta Phys. Med. Soc. Cæs. Leop. Carol. n. cur.* vol. xix, Pl. I, p. 355, Table XXXIII, Fig. 1, *a*, *c*. Entire length two inches, the body about ten lines. The granulation appears to be uniform, it forms a diagonal row of larger tubercles on the rings and lateral lobes, accompanied also by smaller ones. The caudal shield exhibits radiating folds, which turn towards the larger spines of the margin of each side; between the first and second of these spines there is one smaller spine, between the three following there are always two; the two most central principal spines immediately at the end have no smaller spines between them.

Second Subdivision (b).

Ten-jointed Trilobites with a short articulated caudal axis. Animal not able to roll itself into a ball.

Genus 5.—Bronteus,* Goldf. (Goldius de Koninck).

The caudal shields of this genus are common enough, but all the other parts are so rare, that I have never had an opportunity of observing them. The character of the group may possibly therefore be defective.

The cheek-shields are always broken off from the cephalic shield, whence Goldfuss inferred their actual absence, which to me, however, does not appear probable; the remaining part has a highly reflexed margin both before and behind, and a depressed glabella joining the margin anteriorly. The glabella is divided by lateral bent intersections into four lobes, which are successively smaller from the anterior to the posterior part, and contracted at the third and fourth lobe. The facial suture, which, in my opinion, borders the cephalic shield on both sides, issues at the anterior part from the margin near the angle of

*Dr. Beyrich has recently communicated additional information concerning this genus, in his treatise on 'the Trilobites of Bohemia,' and has endeavoured to determine the distinction of the species more accurately. He proves that some species possess a granulated and others a lineated surface of shell, and further distinguishes them according to the number of furrows at each side of the caudal shield, which amount to either six or seven.

the glabella, runs on both sides rather curved towards the eye, which seems to be situated beside the narrowest part of the glabella. It then forms over it the well known covering-plate, and turns itself with an S-shaped curvature towards the posterior margin, where it seems to terminate not far from the external angle.

The ten rings of the body are short, almost as broad as their lateral lobes, and are diagonally arched; the lateral lobes towards the exterior part are flat, with a strong curvature backwards.

The caudal shield is very large, circular, or slightly parabolic; it contains at the anterior part a very short one-jointed axis, from which radiating furrows and broad ribs proceed to the sides.

Locality.—In Devonian and upper Silurian strata.

1. *Br. flabellifer:* Superficie tota granulata; costis scutæ caudalis quindecim, sulcis latitudine æqualibus, serie granulorum majorum notatis. Long 1½-2½″.

Ref.—Goldf. *l. c.* 361, Fig. 3. Leonh. u. Bronn. *Jahrb.* 1843, 349. 3. Tab. XVII, Fig. 3. Roemer. *Verst. d. Harzes.* 37. 1. Tab. XI, Fig 1.

The granulation on the cephalic shield consists of tolerably large tubercles, between which there are some very small ones; the rings of the body and lateral lobes have a diagonal row of tubercles; the almost circular shield exhibits fifteen elevated ribs, which are divided by nearly equally broad intervening spaces, and on each rib there are many nearly equally large tubercles, three or four together, the central being largest and most prominent. The centre of the entire shield is convex; it becomes flattened towards the margin, and expands into a horizontal border.

Remarks.—Count Münster has figured (*Beitr. z. Petref.* iii, Tab, V, Fig. 13) several fragments which belong to caudal shields of *Bronteus*. Fig. 13, *B. radiatus*, Fig. 15, *B. subradiatus*, appear to me hardly to differ from *B. flabellifer*. Fig. 14, *B. costatus*, Fig. 16, *B. Neptuni*, have a longer axis. The former has the same number of ribs as the species now before us, but is very different in size and structure. The latter (*B. Neptuni*) seems to approximate to *Ent. laticauda*, Wahl., in its nine flat ribs.

2. *Br. laticauda:* Superficie glabra, transverse lineata; costis scutæ caudalis tredecim, latis, planis. Long. ?

Ref.—Wahl. *N. Act. Ups.* viii, 28. 3. Brong. *Crust. foss.* 24. 5, Pl. III, Fig. 8. Schloth. *Petref. Nachtr.* ii. 22. 5. 35. 12. Dalm. *Palæad.* 52. 13. and 71. 18. Beyrich, *Böhm. Tril.* 42. 4. f. 8. 9.

Wahlenberg described specimens obtained from a white limestone from Osmundsberg, in Dalecarlia, and the fragments which I examined in the Berlin Museum (Nos. 7. 1-4.) were heaped together in a very similar deposit. The cephalic shield consisted as usual of a single central piece having an anterior and posterior strongly reflexed margin, the former being narrow and strongly curved, the latter rather broader, but less strongly arched. The curvature may have corresponded with the rings of the body. A stamp-shaped, slightly lobed glabella occupied the whole central part, and became broader at the anterior margin laterally. Close to it at each side the nearly circular cheek portion arched itself, and at the posterior margin of this a covering plate for the eye seemed to be indicated. I did not find any cheek-shields. The caudal shield was more parabolic, had a nearly equilateral

triangular axis and thirteen narrow flat radiating ribs, six on each side of the odd central one. Of these ribs the odd one only (left at the end) is straight; the other six pair, the symmetrical lateral ones, are somewhat curved in the shape of the letter **S**.

Remarks.—1. Wahlenberg, in the place already quoted, has figured a fragment which does not belong to the genus *Bronteus*. The caudal shield also does not resemble accurately the one I have described, for it has only nine short broad ledges, which, however, are so unsymmetrically arranged that they are of themselves sufficient to convince us that the drawing is erroneous. I do not venture to decide whether Count v. Münster's *B. Neptuni* (see remark on the last species) belongs to the present form.

2. The genus *Lichas* of Dalman (*Palæad* 53, iv, and 72. *Entomostr. laciniatus.* Wahl. *l. c.* 34. 8. Tab. II, Fig. 2. Brong. *l. c.* 35. 3. Pl. III, Fig. 3. Schloth. *Nachtr.* ii, 36. 19. Milne Edw. *Cr.* iii, 344. 3), which appears to me most nearly allied to *Bronteus*, I am obliged to omit, because the fragments that have come under my observation exhibit nothing to characterize it.*

Division C.

Trilobites having a simple but very small caudal shield, the axis of which is many-jointed, but which is always shorter than the body. Olenidæ.

The two genera, *Paradoxides* and *Olenus*, belonging to this division have been hitherto united by the authors, but are distinguished readily and safely by the caudal shield, which in *Paradoxides* has no lateral enlargement at the base, while in *Olenus*, on the other hand, it is enlarged at that region, and thus generally assumes a trilateral shape; the former genus has from sixteen to twenty, the latter fourteen body-rings.

Genus 6.—Paradoxides, Brongniart (Olenus, Sect. 1, Dalman).

Cephalic shield lunate, with a thickened but not reflexed margin; the glabella clavate or oval, moderately convex; enlarged anteriorly, divided into four portions by three curved sutures, of which the posterior is the margin of the articulation with the body. The lower part of the head (Pl. I, Fig. 7, *Ent. bucephalus*—Wahl. et auct.) has a less prominent boss, analogous to the anterior division of the upper part, which diminishes posteriorly, and is terminated by a convex reflexed margin, having at each side an oblique transverse impression.

The facial sutures are nearly parallel in their principal direction, commencing at the anterior margin on a line with the eyes, turning towards the eye with an **S**-shaped curvature, forming a slightly arched lid, and returning in a similar **S**-shaped curve towards the posterior margin.

Eyes oblong, lunate, depressed, corresponding with the second division of the glabella, reaching towards the anterior part nearly to the centre of the first division, and towards the posterior margin rather beyond the commencement of the second; eyelid rather more convex than the neighbouring part of the cheek.

Cheek-shield narrower than half the width of the cephalic shield, having a curved

* Portlock, Lovèn, and Beyrich have since published descriptions which give a tolerably perfect idea of this form. It appears from their accounts that Dalman's *Ampyx? pachyrhynchus*, Green's *Paradoxides Boltoni*, Castelnau's *Platinotus* and *Actinurus*, Eichwald's whole genus *Metopias*, and Portlock's *Nuttainia hiberuica*, all belong to one genus, which ought to retain its earliest name of *Lichas*. Dr. Beyrich has undertaken to describe the species.

groove before the lateral margin, which impression is continued posteriorly, and returns into itself at the posterior margin of the cephalic shield; the external border is slightly convex, and produced at the posterior part in a long slightly incurved spine.

Body many-jointed, apparently only having a definite number of joints in the separate species (16-20), the joints towards the posterior part gradually more narrow and shorter, the lateral lobes at first produced diagonally, and in this part almost as broad as the rings of the body; afterwards projecting in a long angle turned outwards and backwards; a deep diagonal impression on the transverse portion, which extends from the most anterior and innermost angle backwards, to the origin of the spine.

Caudal shield circular or oval, without (?) lateral lobes and enlarged sides at the base, with a short but articulated axis, and a flat border to the posterior portion.

Locality.—In the oldest Palæozoic strata (grauwacké, clayslate, and alumslate); hitherto only found in Bohemia, Sweden, and near St. Petersburg.

Remark.—I know only two distinct species of this genus from my own observation, and confine myself here to the description of these two, but in so doing would not be understood to question the propriety of the others to rank as species. Naturalists having an opportunity to investigate perfect specimens of the species which I have not admitted, will be able to decide how far they really differ from the two here enumerated.

1. *P. Bohemicus:* Protuberantia capitis clavata; angulis scuti cephalici dimidio corpore longioribus; trunco vicies annulato. Long. 1-6."

Var. juven: annulis trunci 18; lobo laterali secundo in spinam longissimam extenso. Tab. I, Fig. 6.

Ref.—*Olenus pyramidalis*, ZENKER, *Beitr. etc.* 41. Tab. IV, Fig. T. U. V. *Tril. gracilis*, BOECK, *Magaz. f. Naturw.* I, Fig. 15. STERNBERG, *Verh. d. Vaterl. Mus.* 1825, Tab. I, Fig. 4, C, and 1833, p. 47.

Etate paulo provectior (?) *Tril. minor* BOECK, *l. c.* f. 12, 14.

Var. senilis: annulis trunci 30; lobo laterali secundo reliquis æquali. Tab. I, Fig. 5.

Tril. bohemicus, BOECK, *l. c.* f. 2. STERNBERG, *l. c.* 1825, 83. Tab. I, Fig. 4. A. B. 1833. 46. KINSKY, in *Bora's Abhandl. etc.* I, 246, Fig. 4, 5, 7. *T. longicaudatus*, ZENKER, *Beitr.* 37, Tab. 5, Fig. A to F. EMMR. *Diss.* 48. 4. MILNE EDW. *Crust.* iii, 341. 2. *Olenus Tessini*, Var. 1. DALM. *Palæad.* 73.

Central part of the cephalic shield rather quadrate, but the distance between the eye-plates rather greater than the longitudinal diameter; the anterior round lobe of the glabella longer than the three others together. Spines of the maxillary shield longer than half the body; the spine of the second ring of the body as long as this during the youth of the animal, gradually getting shorter, and finally reduced to the same length as the spines of the other body-rings. Rings of the body less numerous during youth (sometimes sixteen, usually eighteen), at a more mature age probably always twenty (at least I have never seen a greater number in perfect specimens). Caudal shield quite oval, rather broader towards the posterior part, almost flattened, the axis inarticulated during youth, afterwards one-jointed, at maturity furnished with five joints.

Locality.—In a blackish-green grauwacke of Bohemia, near Horrowic and Ginec: also in Norway and Sweden, in the latter in alumslate, at Olstrog, Dammen and Carlsfors.

Remarks.—1. *Ol. pyramidalis*, Zenker (*Tril. gracilis*, Boeck) I can only agree with Count Sternberg in regarding as a young specimen of the *Tr. longicaudatus* and *Tr. bohemicus* of the same author, and

this view is supported not only by the relative proportions of the body which perfectly correspond, but also by the delicate nature of the covering, and the long slender spines. The remarkable prolongation of the second lateral spine (not the third, as Boeck and Count Sternberg have already correctly shown while controverting Zenker) indicates some peculiarity relative to the young age of the animal (at least so far as it seems to have formed a pair of forceps with the long spine of the cephalic shield). The length in this case gradually decreases as the others increase, but is still distinctly visible in individuals that are half grown. I look upon *Tril. minor*, Boeck, as an instance of this kind. That the rings of many-jointed Crustaceans increase in number as the animal grows, and that this number is only complete when the animal is fully grown, is a fact too well known to the naturalist to require proof in this place, but on this subject I would refer to my own investigation of the *Phyllopoda*, and the elaborate and new observations of Zaddack and Joly. (*Ann. des Sc.* n. s. 1840 and 1842.)

Oleuus latus (Zenker *l. c.* Figs. W, X. Milne Edw. *l. c.* 111, 3) is distinctly the same species as the one above described, and is merely flatly compressed.

2. The species *Paradoxides seu Oleuus Tessini* (*Entom. paradoxissimus*, Linn. *Mus. Tess.* 98, Tab. III, Fig. 1; Wahl. *Nor. act. Ups.* viii, 34, Tab I, Fig. 1; Brongn. *Cr. f.* 31, Pl. IV, Fig. 1; Schlot. *Pet. Nacht.* ii. 23. 1. 35. 15; Dalman, *Pal.* 54. 1. 73. 1. Tab. VI, Fig. 3; Boeck, *Mag. f. Nat.* I. 26; Buckland, B. T. Pl. XLVI, Fig. 8; Bronn. *Leth.* I, 120, Tab. IX, Fig. 16; Quenstedt, *Wieg. Arch.* 1837, 348; Emmr. *Diss.* 48; Milne Edw. *Cr.* iii. 340, 1, Pl. XXXIV, Fig. 11; Hising. *Leth. suec.* 18, Tab. IV, Fig. 1) appear to me, judging from the representations and descriptions enumerated above, to be scarcely different from *P. bohemicus*: at least I find no certain and available difference. In Linnæus's oldest figure there have been indicated at most seventeen body-rings, and the caudal shield has here been distinctly represented without lateral lobes. Wahlenberg represents twenty-one such rings, and twenty-two lateral lobes, the last pair of which is affixed to the caudal shield itself. Dalman's figure represents a similar caudal shield, but only twenty body-rings; and both authors state that they have only examined imperfect fragments, and make out no more clearly the caudal shield. Brongniart copied from Wahlenberg; Buckland, Bronn, Milne Edwards, and Hisinger from Dalman. I consider therefore the figure given by Linnæus of the caudal shield, and Dalman's enumeration of the body-rings to be correct, and I thence infer that *P. Tessini* is specifically identical with *P. bohemicus*.

3. Wahlenberg (Tab. I, Fig. 7) has figured the impression of the under side of a cephalic shield (the hypostoma) as a distinct specific form, under the name of *Entom. bucephalus* (*l. c.* 37. 10, Tab. I, Fig. 6). Following in his footsteps, we find Dalman (*Pal.* 55. 2), Schlotheim (*Nacht.* ii. 37), Boeck (*Mag. f. Nat.* I, Fig. 16), Milne Edwards (*Cr.* iii, 341), and Hisinger (*l. c.* 18) expressing the same view more or less doubtingly. More recently Sars (*Isis* 1835. 342), Quenstedt (*Wieg. Arch.* 1837, I. 349), and others, have recognized the identity of the structure with that of *P. bohemicus*, and M. v. Buch has shown me some specimens which show the fact in a very instructive manner. I have figured such an under cephalic surface in Tab. I, Fig. 7. The concentric lines there visible may be observed in all under surfaces of Trilobites, and have already been alluded to by Zenker, in the work already cited, Figs. C. D.

P. spinulosus: Protuberantia capitis parabolica; angulis scuti cephalici dimidio corpore brevioribus, trunco sedecies annulato. Long. 1″.

Ref.—Linn. *Act. Holm.* 1759, 22, Tab. I, Fig. 2. Wahl. *N. a. Ups.* viii, 38. Tab. I, Fig. 3. Brong. *Cr. f.* 32, Pl. IV, Figs. 2. 3. Schloth. *Nachtr.* II. 25. 2. 36. 16. Dalm. *Pal.* 56. 2. 73. 2, Tab. V, Fig. 2. Emmr. *Diss.* 47. 5. Quenstedt, *Wieg. Arch. l. c.* 349. Milne Edw. *Crust.* iii. 342. 5. Hising. *Leth. Suec.* 19, Tab. IV, Fig. 2.

I have seen only a few and not very distinct specimens of this species, but these corresponded with Wahlenberg's and Brongniart's figure in the principal points. The cephalic shield exhibits a glabella which is not broader anteriorly, but is gradually rounded towards that part, with three slight impressions at each side. I counted sixteen rings in the body,

the exact number which seems to have been seen by Dalman, whilst seventeen have been given in his and Wahlenberg's figure. Brongniart's very excellent figure exhibits also sixteen, probably the correct number. The lateral lobes of the first body-rings are very broad, broader than the axis, but they rapidly get smaller posteriorly, so that the last become narrower than the axis. The caudal shield is small, roundish, transversely elliptical, and has no lateral lobes.

Locality.—The same as *P. bohemicus* and *P. Tessini;* and also in the clayslate of Angers, associated with *Oggygia Guettardi.* (Vide Guettard, *Mém. de l'Acad des Sciences,* tom. xiv, ann. 1757, Pl. VI, 8, Figs. 3. 4. 5.)

Remarks.—Various species hitherto imperfectly known appear to belong to this genus. Among these are—

1. A figure by Count Razoumousky, in the Annales des Sciences (t. viii, Pl. XXVIII, Fig. 11). While possessing a similar structure with *O. bohemicus,* this specimen is distinguished by a long spine at the extremity of the caudal shield. *Locality.*—In Silurian strata between St. Petersburg and Lake Ladoga.

2. *Paradox. Boltoni,* Bigsby (Green, *Mon.* 60, f. 5, *Journ. Ac. N. S. of Phil.* vol. iv, p. 365, Pl. XXIII. Harlan, *Zool. res.* 303. Milne Edw. *Crust.* iii, 311, *n.* 1). This genus, as we have already seen, belongs to the genus *Lichas,* Dalman. See Remark 2, under *Bronteus laticauda.*

3. *Calym. actinura* (Dalman, *K. V. Ac. Hand.* 1824, 370, Tab. IV, Figs. A, B, C. Hising. *Leth. suec.* 11, Tab. I, Fig. 7. Milne Edw. *Crust.* iii, 321). A species having fifteen (?) lateral lobes and body-rings, and resembling so closely in every respect *P. Boltoni,* that I cannot but refer them to the same genus, intermediate between *Bronteus* and *Paradoxides,* the characters of which cannot yet be determined with certainty.

4. *Parad. Harlani* (Green, *Silliman's Am. J. of Sc. and Arts,* vol. xxv, p. 336. Harlan and Milne Edw. as before cited).

5. All the other species hitherto included among *Paradoxides* or *Olenus,* probably belong to the following genus.

Genus 7.—Olenus (Paradoxides *et* Olenus *Auctorum*).

Cephalic shield constructed as in *Paradoxides,* but comparatively broader and shorter: the glabella parabolic, not broader towards the anterior part, but rather more narrow and rounded, at each side furnished with three slight furrows, which separate it into four divisions, of which the posterior narrow one is articulated with the body.

Eyes oblong curved. The facial suture originates at the anterior margin, in the region of the eye. It is there bent at an angle, and returns nearly parallel to its former direction towards the eye, where it makes a bent plate, and passes in an **S**-shaped curve towards the posterior margin, where the two sutures gradually and continually diverge.

Cheek-shield tolerably broad, with a reflexed margin, and with a pointed but not very long posterior angle.

Axis of the body many-jointed (fourteen?); the joints more narrow than the lateral lobes, short, and moderately convex; the lateral lobes extended in a straight line, only terminating at the end in a short point directed backwards; each furnished with a diagonal furrow from the anterior and internal towards the posterior and external part.

Caudal shield much broader than long, semicircular, straight at the anterior part, arched or obtusely angular, trilateral posteriorly, with a distinct articulated axis.

Locality.—In very old strata with species of the preceding genus.

1. *O. gibbosus:* Scuto capitis inter suturam facialem et umbonem tuberculo transverso signato; rhachi corporis quaterdecies annulata, caudæ quinquies. Long. 1″. Table III, Fig. 9.

Ref.—*Tr. truncatus*, Brünn. *N. Act. Hafn.* i, 391. Modeer in *Berl. Gesellsch. Schrift.* vi, Table II, Figs. 3-5. *Entom. gibbosus*, Wahlenb. *N. A. Ups.* viii, 39. 12, Table I, Fig. 4. Brongn. *Cr. foss.* 35, Pl. III, Fig. 6. Schloth. *Nachtr.* ii, 26. 4. 36. 18. Dalm. *Palæad.* 56. 4. 74. 4. Boeck, *Mag. f. Nat.* i, 24. Emmr. *Dissert.* 45. 1. Milne Edw. *Crust.* iii, 343. 4. Hising. *Leth. suec.* 19, Tab. IV, Fig. 3.

Cephalic shield four times as broad as it is long, the axis remarkably narrow; an elevated elliptical prominence both to the left and right at the anterior extremity, the prominence extending as far as the facial suture.* The number of joints in the axis of the body is fourteen; the lobes of the first joints are twice as broad as the axis; those of the last only a little broader.

Caudal shield semicircular; the axis five-jointed, with an anterior margin of articulation; the lateral portions flat, without rays, the margin rather reflexed.

Locality.—In the alumslate and stinkstein of Andrarum.

Remarks.—1. The cheek-shields of the head are absent in all the older descriptions and figures, being always broken off. They are often present, however, near the other remains, so that there can hardly be a doubt about their existence. I counted fourteen body joints in the impressions of young and perfect individuals.

2. *Asaph. tetragonocephalus* (Green, *Sill. Am. Jo.* vol. xxv, p. 336; Emm. *Diss.* 46. 4; Milne Edw. *Cr.* iii, 330) is so similar to *Ol. gibbosus*, that they are liable to be confounded with one another; indeed I was not able to discover satisfactory specific distinctions in the plaster model which I examined at Berlin. I counted in this specimen fourteen body-rings, and certainly three caudal rings, but the latter were indistinct and imperfect. The species was found in the alumslate of Loekport.

3. Boeck, in Kielhau's *Gea Norwegica* (see Leonhard and Bronn, *Zeitshr.* 1841, p. 727), has characterized two species nearly related to *Ol. gibbosus*, which I am not acquainted with, and therefore give them here according to his statement.

O. alatus (*l. c.* No. 38) is nearly related to *O. gibbosus*, but the glabella (which is the only part known) is proportionably much narrower, and the transverse prominence which issues from its anterior extremity does not extend in so straight a line, but is produced more backwards.

O. latus (*l. c.* No. 39) is much larger than *Ol. gibbosus*, and the piece (probably the space) between the glabella and eyelid is considerably broader.

I do not think such differences in imperfect fragments can justify us in founding new species.

4. Emmerich's *Par. acuminatus* (Dissert. 46. 2), which is said to be distinguished from *Ol. gibbosus* by a more developed angularity of the facial suture before the eye, and by a bending of it inwards at the posterior extremity, also appears to me merely to indicate an individual difference caused by difference of preservation, as this is easily accounted for in the impressions of tender parts. *Ol. gibbosus* in other respects varies, like its allies, very considerably in size, according to the difference of age; I have seen specimens of 1½″ length, and others scarcely ½″.

2. *O. forficula.*

Sars, *Isis*, 1835, 333, Tab. VIII, Fig. 1. Milne Edw. *Crust.* iii, 343. 1.

According to the figures, this species most nearly resembles *Parad. spinulosus* in the habit of the head (*im Habitus des Kopfes*), but has a glabella somewhat broader anteriorly, and divided by two furrows into three nearly equal parts. A slight longitudinal impression appears at the anterior of these, and on the third there is a small tubercle. Behind it the

* By its position this prominence justifies the assumption that a small tentacle issuing from the glabella has existed beneath it in a cavity of the shield.

swelling of the margin makes a fourth division. The facial suture terminates as in *Olenus*, and the terminating angle of the cheek-shield is elongated.

The caudal shield is semicircular, straight at the anterior part, bounded by a curve at the posterior part; the axis consists of five to six rings, and a fold proceeds from it towards the posterior margin, which there projects in a large spine. This is all that is known of the animal.

Locality.—A calcareous blackish-gray alumslate of Rusielökbacken, near Christiania.

Remarks.—1. According to Boeck (*Gea norw.* i, No. 18), this species is not properly placed here, but forms with *Ceraurus pleurexanthemus* (Green, *Mon.* 84, f. 10; Bronn, *Let.* i, 117, Tab. IX, Fig. 12; Milne Edw. *Cr.* iii, 346) a distinct genus. It is very probable that this view is correct, but since I have not myself had the opportunity of examining the two species, I must leave the decision to others. No doubt, however, *Ceraurus* represents a form closely related to the *Olenides*. In Green's figure eleven body-rings and a broad caudal shield are represented, the latter bearing a spine on one side exactly like that of *O. forficula*.*

2. Murchison (*Sil. Sys.* vol. ii, p. 658, Plate XIV, Fig. 8) has described a large caudal shield, to which he gives the name *Paradoxides bimucronatus*, and this in many respects seems to hold an intermediate place between the caudal shield of the last and of the next succeeding species. It is straight at the anterior part, nearly an inch in width, and furnished with a three-jointed axis, over which there projects forwards one of the articulation. A fold proceeds to the margin from each ring, and the three folds, like the rings themselves, become smaller posteriorly, so that the free semicircular margin is furnished with six rather bent processes.†

3. *O. scarabæoides:* Scuto capitis convexo, vertice non elevato sublobato; scuto caudali utrinque tridentato, axi biarticulata.

Ref.—Bromel, *Act. litt. Ups.* 1729. 521. *n.* 3, and page 528. 6, *c* Fig. Wahl. *N. A. Ups.* viii, 41. 13, Tab. I, Fig. 2. Brongn. *Cr. foss.* 34. 3, Plate III, Fig. 5. Schloth. *Nacht.* ii, 25. 3. 36. 17. Dalm. *Palæad.* 57. 5. Emmr. *Dissert.* 47. 6. Milne Edw. *Cr.* iii, 344. 1, *Pellura scarab. Anthes scarabæoides*, Goldf. *Leonh. und Br. Jahrb.* 1843, p. 544.

Of this species I am only acquainted with some fragments of heads and perfect caudal shields, and from these I must declare it to be a species with which I am too little conversant to judge with certainty respecting its systematic position. The glabella resembles that of the first described species of this genus, but is relatively shorter, broader, more convex, and the indentations, which are similarly divided, are slighter. The existing part of the cephalic shield beside it is deeply depressed, and thereby indicates a very great convexity of the cheeks. I think I recognize a trace of the eyelid in the region of the first anterior suture; a distinctly reflexed margin is visible at the posterior part; but I have never distinctly seen the anterior and lateral margin. The caudal shield has a short two-jointed axis, and a margin of articulation before the first joint; it is extended on both sides more

* A new species of *Ceraurus* has been described by Portlock (*Rep.* 257, Plate I, Fig. 7) as *C. globiceps*.

† In his treatise '*Ueber einige Böhmische Trilobiten*,' Dr. Beyrich has shown that this species of Murchison's, together with *Tril. Sternbergi*, Boeck, constitute a new genus, for which he proposes the name *Chirurus*. He describes four Bohemian species of this genus, and includes also in it *Calymene Sternbergi*, *C. propinqua*, and *C. articulata* of Münster (*Beitr. z. Pet.* iii, 37, Tab. V); *C. speciosa*, Dalman (*Pal.* 74); *C. ornata*, Dalm. (*Arsber. om ngn Zool. Arbet.* 134); *Amphion gelasinosus*, Portlock (*Rep.* 289, Plate III, Fig. 4); and *Acres planospinosus*, Portl. (*l. c.* 272, Plate V, Fig. 9); the two latter being probably the cephalic and caudal shields of the same species referable to this genus (*Chirurus*).

than usual posteriorly, and is there furnished with a deep transverse furrow before the straight margin, and is drawn out at each side into three pointed marginal processes, which are situated lower than the general surface, and which issue from the deflexed margin.

Locality.—The alumslate of Andrarum.

Remarks.—1. Wahlenberg, who states that he has seen a perfectly preserved individual of this species at Copenhagen, describes it as having twelve body-rings with very short lateral lobes, which are pointed towards the posterior part; he has, however, represented the glabella and the caudal axis much too broad, and for this reason I am inclined to consider the body axis as also too broad.

2. Harlan (*Med. and Phys. Rec.* 400 *et seq.*) describes two new forms, nearly related to *Par. scarabæoides*. He speaks of them as *Parad. triarthrus* (*l. c.* 401. 1, Fig. 5), and *Parad. arcuatus* (*l. c.* 402. 2, Figs. 1, 2, 3). Both are from the carboniferous strata (?) of Utica, in New York. They are imperfect heads, which certainly resemble the fragments of *Ol. scarabæoides*, but which still require a further investigation as to their true organization. The author compares them with *Triarthrus Beckii* (Green, *Mon.* 87, Fig. 6), with which they certainly seem to be related.

3. I shall treat more particularly in the Appendix of *Triarthrus Beckii* and *Trilobites Sternbergi*, which probably belong to the *Oleneides*.

4. I beg once more to remind my readers that I have mentioned *Paradoxides spinulosus*, *Olenus forficula*, and *Olen. scarabæoides*, as species which are both imperfectly known to me, and the correct arrangement of which in systematic order I cannot guarantee; this is still more the case with the other species of other authors, which I have only enumerated here hypothetically.

GROUP THE SECOND.

The lateral lobes of the body-rings not horizontally extended in their whole length, but turned downwards from the centre, and not terminating in a point, but with an arched and rounded extremity. Furrowed on the surface along their whole length. CAMPYLOPLEURI.*

I am only perfectly acquainted with the first two of the three genera enumerated in this group; they are recognizable by their smaller, semilunar, cephalic shield, by their fewer number of joints (twelve to fourteen), and by their simple, semicircular, caudal shield. The one, *Conocephalus*, has fourteen rings; the other, *Ellipsocephalus*, twelve. The third genus, *Harpes*, has a very large cephalic shield, shaped like a horseshoe, with long posterior angles, and is stated to have twenty-eight rings.

Genus 8.—CONOCEPHALUS, Zenker.

Cephalic shield not unlike a half-moon, but the posterior internal margin only slightly bent. Glabella separated by a deep furrow from the lateral lobes, becoming more narrow towards the anterior part, divided by four furrows at each side into four lobes, and becoming broader from the anterior to the posterior part; behind the fourth lobe there is a reflexed margin of articulation. The lateral parts, together with the cheek-shield, are highly convex, surrounded by a furrow and by a thickened margin.

Eyes small, but certainly present; partly fixed at the anterior part beside the angles of the glabella, partly at the centre of the sides.

* The following generic names, and the names of larger groups thence derived, have been already made use of to designate various tribes of Locusts.

The facial suture commences at the anterior margin far towards the outer side, turns inwards with a curve towards the eye, forms a small covering plate, and then runs towards the posterior angle, before which near the inner part it penetrates the posterior margin. The angle itself is furnished with a short straight spine.

Body fourteen-jointed, the axis narrower than the lateral lobes, very convex; the lateral lobes quite horizontal, of equal breadth, deeply sulcated in their whole length; from the centre they begin to curve downwards almost at a right angle, and are rounded at the extremity; they are separated at the base from the axis by a deep furrow.*

Caudal shield semicircular, very convex anteriorly, with a five-jointed axis, and slight furrows on the sides.

Locality.—In the grauwacke of Bohemia, at Ginu.

1. *C. Sulzeri:* Oculis juxta apicem tuberculi frontalis. Long. 1½-1″. Table I, Fig. 10.

Ref.—Kinsky, in *Born's Abh. etc.*, I, Figs. 1, 2, 3. *Trilob. Sulz.* Schloth. *Nachtr.* ii, 28. 1, and 34. 5, Table XXII, Fig. 1. Dalm. *Palæad.* 75. 1. Sternb. *Verhandl. d. vaterländ. Mus.* 1825. 81. 4, Table II, Fig. 1, A. Boeck, *Mag. for Natur. Sc.* Figs. 20, 21, *Trilob. Zippii. Conoc. costatus*, Zenk. *Beitr.* 49. 15, Table IV, Fig. G-K. Milne Edw. *Crust.* iii, 336.

Syn.—*Conoc. Sulzeri*, Bronn, *Lethæa*, 1. 121. 110, Table IX, Fig. 15. Emmr. *Diss.* 43. 1. Quenst. in *Wiegm. Archiv.* 1837, i, 347.

Glabella very much contracted anteriorly, and almost rounded; before it, and behind the thickened margin, there is a peculiar transverse fold.

Eyes small, situated on tubercles immediately beside the anterior angles of the glabella, whence the facial suture continues directly across the sides, dividing the narrow cheek-shield.

Body rings and caudal shield not remarkable.

2. *C. striatus:* Oculis in medio partium lateralium scuti cephalici. Long. 1½-2″. Table I, Fig. 9.

Ref.—Emmr. *Diss.* 43. 2, C fig. *Trilob. Sulz. var.* Sternb. II, 1, A, and Table I, Fig. 3. Quenstedt, *l. c.* 348.

Similar to the preceding species in size, habit, and structure; but the cephalic shield totally different. The glabella at the anterior part is broader, straightly truncated, and merely furnished with rounded angles; there is no transverse fold in front of it.

The eyes are more distinct, attached to the centre of the lateral parts of the cephalic shield, and bearing the same proportion to the facial suture; but a sharp ridge extends itself towards them from the angles of the glabella.

The cheek-shields are not narrow and elongated, but short and broad, and only reach half as far anteriorly as in the last species.

Boeck was the first to point out the differences which constitute this a species, although Count Sternberg had previously observed it. By mistake, however, he confounded the

* Zenker (*l. c.*), and after him Quenstedt and Emmerich, regard this furrow as the indication of an articulation or suture; but since in every specimen the impression is merely that of an internal shelly surface, the indentation is more probably the impression of an elevated ridge, which may have served for the insertion of the muscles of the legs. The analogy of all other Trilobites is against the existence of a suture.

names, regarding the true *C. Sulzeri* as the new species. Quenstedt acknowledged the points of specific difference without noticing what had been done before; and Emmerich at length gave the name.

Genus 9.—Ellipsocephalus, Zenker.

Cephalic shield similar in outline to that of the preceding genus, but quite distinct in construction, being flatter and without posterior prolonged angles; the anterior margin also is not elevated.* The glabella is divided from the shield by a slight indentation, equally broad, rounded at the anterior part, without transverse furrows, and even without a posterior articular fold.

Eyes oblong lunate, very narrow, and projecting outwards. Facial suture short, commencing at the anterior part at the margin before the eyes, and curving over them towards the posterior angle. Joints of the body twelve, the axis nearly as broad as the lateral lobes, depressed. The lateral lobes at first horizontal, rather flat, and almost without furrow; then curved downwards, more deeply furrowed, but the furrow pointed inferiorly; with an anterior surface transversely affixed, indicating a deficiency of power in the creature to roll itself into a ball. The extremity is thus rendered obtuse-angled.

Caudal shield small, semicircular; the axis one-jointed.

Locality.—The Palæozoic rocks (grauwacke) of Bohemia. The only known species attains a length of about 1¼ inches, and is *E. Hoffii*. Table I, Fig. 8.

Ref.—Kinsky in *Born's Abhandl.* 1. 246, Fig. 6. *Trilobites Hoff.* Schloth. *Nachtr.* ii, 30. 2, and 34. 6, Table XXII, Fig. 2, *a*, *b*. Count Sternberg, *Verhandl. d. vatal. Mus.* 1825. 83, Table II, Fig. 4, and 1833. 50. Dalm. *Palæad.* 76. 2. Boeck, *Mag. f. Naturv.* 1, Figs. 14, 17, 19.

Syn.—*Ellipsocephalus ambiguus*, Zenk. *Beitr.* 51, Table IV, Figs. G, K. Milne Edw. *Cr.* iii, 344. *Ellips. Hoffii*, Bronn, *Lethæa*, 1. 122. 111, Table IX, Fig. 18. Emmr. *Dissert.* 44, VI. 1. *Calymene decipiens*, König, *Icon.* sect. i, 2, Table III, Fig. 32.

Genus 10.—Harpes, Goldfuss.

Cephalic shield very large, in the shape of a horseshoe, very convex in the centre, flatly expanded at the whole external margin; the posterior angles long, and projecting beyond the centre of the body. The glabella is very prominent, oval, and does not reach to the anterior margin; it becomes narrower at the posterior part before the margin of articulation, and is furnished with a double impression, which separates two elliptical lateral lobes from its posterior half; by the side of it externally there is also a slight trace of a third arch-like impression and lobe.

Eyes indistinct, small, appearing in the shape of knobs at both sides beside the anterior half of the glabella.

* The impressions occur in two kinds of forms; some have no elevated margin, others only exhibit the impression of it as an indentation in the matrix. According to this, there seems to have been a reflexed margin only at the lower side of the cephalic shield. This appears to me to be the case also with regard to *Conocephalus*.

Facial suture indistinct; I can perceive only a slight indented arch, which issues from the place at which the border and central shield meet together. This line turns towards the eye-tubercle, and separating from the latter at the posterior part, makes another turn with a sharper curvature, over the posterior half of the sides to the angle, which is formed by the open posterior margin and by the lobes of the angle.

Body many-jointed (above twenty), the axis very convex, narrowing posteriorly, but elsewhere quite as broad as the lateral lobes; both these are short, the latter at first horizontal, slightly furrowed, bent much downwards at the end, and obtusely pointed.

Caudal shield not known.

Locality.—Upper Silurian and Devonian strata of the Eifel, the Fichtelgebirge, Bohemia, and Ireland.*

Remarks.—1. Of this genus I have before me only a single cephalic shield, but this is for the most part well preserved; it lies in a yellowish, liver-brown limestone, probably the same in which is also found *Odontopleura ovata*, and has, like the latter Trilobite, preserved its real shell, partially at least. This shell is punctated with little indentations at all parts where it has not been damaged, but the punctation is uneven, so that the largest indentations are situated immediately at the circumference of the real cephalic shield, where the flat border proceeds from it; and they decrease in size from this point both towards the inner and outer part. A fine marginal ridge runs quite round the open margin of the border, and before it there is a row of larger indentations. The eyes are wanting in the specimen I possess, but their places are indicated.

2. Count Sternberg first described a species of this genus as *Trilobites ungula* (*Verhandl. d. vaterl. Mus.* 1833, 52, Fig. 1), in which at least twenty body rings were perfectly distinct. From this Goldfuss constituted the genus (*Nova act. Phys. Med. Soc. Caes. Leop. Carol. nat. cur.* vol. xix, p. 1, 358, Table XXXIII, Fig. 2, *a*, *b*, *c*), and gave a more accurate account of the organization, which was, however, already known. According to him there are twenty-eight body rings. Count Münster endeavoured to enrich the genus by new species (*Beitr. z. Petref.* Parts III and V); but it appears to me that he has often merely taken individual differences for specific characters. This is the more likely since all his specimens, as also those of Sternberg, probably consist of mere impressions, without any remains of the shell. At present, therefore, I can admit only the following species:†

H. ungula: Limbo scuti cephalici antice latiori, punctato; punctis internis majoribus, foraminulosis. Long. sine corp. 1⅓-2″, cum corp. 2-2½″. Table I, Fig. 11.

Otarion pygmaeum, Münster (*l. c.* V, 115, Table X, Fig. 11), appears to me to have been a very young, but mutilated individual; *Otar. elegans* (ibid. I, Table X, Fig. 2) an older individual, but also mutilated; *Harpes macrocephalus*, Goldf. (*l. c.* 359, Table XXX, Fig. 2, *a*, *b*, *c*), and the figure given in this work, represent full-grown, perfect individuals.

Goldfuss's description is detailed and correct; and as my specimen is not so well preserved, I will repeat his words:

"The inverted egg-shaped body is depressed, but the head is considerably elevated, and occupies more than a third of the length of the whole animal. Its circumference is semicircular, and it is surrounded by a broad margin, which at the anterior part is horizontally

* Portlock (*vide* Report, &c., Tab. V) has published figures which prove beyond a doubt that the genus *Harpes* belonged to that group of Trilobites capable of rolling themselves into a ball. It cannot therefore be brought into any near relation with *Trinucleus*, as Portlock supposes, and as Loven has endeavoured to prove (*Öfvers*, &c. 105).

† I no longer hold this view, and am now much rather inclined to regard both Portlock's species as perfectly distinct; and I also am willing to admit at least two of Count Münster's species. That represented in Table V, Fig. 19, 23, is one of these; and the other is that marked Fig. 20, 22. The former reminds one of *Harpes Flanagani*, of Portlock (*l. c.* 268, Plate V, Figs. 5-7); the latter, of his *H. Doranni* (ibid. 267, Plate V, Fig. 4). Count Sternberg's figure more resembles the former than the latter species.

extended, but assumes a more vertical position at the sides, and terminates at each side in a point, which is produced posteriorly for three fourths the length of the animal. Its border is rather thickened, and forms (both on its upper and lower reduplication) an elevated bordering line. From this horseshoe-formed extension of the margin, the head rises anteriorly and laterally with a somewhat steep elevation, and in the middle of the elevated part it has an oval protuberance in the manner of a forehead, which is surrounded by an impressed furrow, and which does not descend to the expanded margin. It forms a keel (a very slight one, *Auc.*) at its highest part, and exhibits a slight fold in front of the furrow on the summit. A small semicircular eye-tubercle is situated on each of the large cheeks, almost at the anterior extremity of this fold, and close to it. Even with the naked eye one can distinguish a somewhat larger round protuberance at the centre of this eye-tubercle, and two oval ones of the same size on both sides.* Behind them may be discovered, with the assistance of a microscope, other small tubercles in regular rows.

"The head terminates posteriorly in a small protuberant half-ring, to which the joints of the central body are united. The protuberance of the forehead and the summit of the cheeks above the eyes, are smooth; and it is only upon the furrow of the former that a few small granulations are perceptible. The rest of the surface of the head is thickly granulated, so that the boundary towards the smooth forehead is distinctly marked.†

"The expansion of the margin is prettily ornamented by a row of larger granulations on the surface, both of its upper and lower plate, and as well at the external as internal margin (i. e. in the cast; in the true shell there are corresponding indentations, and no granulations, *Auc.*)

"From the head to the side of the tail, twenty-eight segments may be counted, becoming gradually and uniformly shorter towards the posterior part. Whether there is also a small simple caudal shield without ribs, cannot be determined from the specimens before us. The high convex spine (the axis) occupies a third part of the whole breadth, and its segments are ring-shaped; the ribs, however (lateral lobes), have only a flat longitudinal furrow, are closely united, and form a flat expansion at each side. Their short ends are obtusely pointed and bent downwards at an angle, so that the body exhibits a narrow border. The anterior ribs (lateral lobes) increase gradually in length‡ as far as the seventh or eighth, and the rest become gradually narrowed again behind them. The spine is granulated, but the sides are quite smooth."

The specimen in my possession has no trace of body rings; but I suppose from the analogy of the cephalic shield that the rings of the axis were also without granules, and merely ornamented with punctures, *Auc.*

* These parts are absent in the specimen which I possess; judging from the figure, I should suppose that only the two oval spots are real eyes, and that the warts are little prominences on the shell. This genus would otherwise be characterized by four eyes, two on either side.

† Goldfuss is here describing an impression without the shell, in fact, a cast in which all the indentations of the real shell appear as protuberances and granulations. In the same way Count Münster describes young individuals for his *Trinucleus*.

‡ The breadth is from left to right.

II.

Trilobites having the power of rolling themselves into a ball.

The distinctive character of this second, more numerous, and principal group of Trilobites is to be sought for in the structure of the lateral lobes of the joints of the body, which at first are continued horizontally, but are afterwards more or less curved vertically downward. At the point of curvature there appears to be a kind of articulation between two successive joints, or, at least, there is a very accurate insertion of one into the other.

The lobe from this point becomes broader outwards and downwards, ceases to be connected with the adjacent ones, and makes a turn, its anterior edge being directed obliquely inwards, to find room by the side of the next preceding. It thus has a surface somewhat turned forwards, obliquely placed, and gradually widening below, extending hence to the posterior margin of the lobe, and only leaving a very small space for the true upper or external side. This space also, the true external surface, gradually diminishes from the point of articulation of the two lobes, and extends to the posterior margin; it is usually rather strongly arched, and divided by a diagonal furrow, which proceeds from the anterior angle, close beside the rings of the axis, and likewise bends towards the external posterior angle. The anterior sharper margin of this furrow forms at the same time the edge, at which the oblique, but always flat, anterior surface meets with the posterior or upper surface. When the animal rolls itself up, the lateral lobes were passed one under another from the point of articulation, each preceding lobe covering the oblique surface of the next so completely, that nothing could be seen of the rolled-up animal except the convex posterior portion. I shall henceforth always call the surface, which is covered during the rolling-up process, the *anterior*, and, on the other hand, the one which remains externally visible, the *external* part; the former being manifestly intended to be concealed, since it is usually covered by the parallel punctured furrows which are found in all Trilobites at the lower surface of the shell, where exposed.

Such punctures are never absent in well-preserved specimens; but the oblique diagonal furrow on the upper side of the rings, on the other hand, is deficient in some genera (*Illænus* and *Nileus*). The boundary between the rings of the axis and the lateral lobes is also more indistinct when such is the case.

There are, however, other characters also more or less directly connected with the power of the animal to roll itself up. As such, we may enumerate—

1. The much larger and more projecting eyes, a character which, since it is wanting in the previous group, has led to the assertion, that most of the members of this group were blind; I have, however, recognized the eyes in almost all of them (except, indeed, *Trinucleus*), and thus refuted, I hope satisfactorily, the notion of blind Trilobites.

2. The tougher nature of the horny membrane. It is at least remarkable that this part is preserved in a fossil state in almost all the members of this group, while in the members of the former group it is only met with when the remains are found in limestones. The Trilobites of this second group, however, occur chiefly in limestone, and the preservation of their shell may therefore be owing to that circumstance.

3. The fact that the size and shape of the caudal shield correspond pretty nearly with the size and shape of the cephalic shield. This is no doubt the case also in *Oggygia*, and partially in *Trinucleus*, but less generally than in the present group. We shall rarely meet with forms in which the caudal shield is much smaller than the cephalic shield; and, on the other hand, we shall find some species in which the former is the greater of the two. The size of the caudal shield can scarcely therefore afford any safe inference with regard to the power of the animal to roll itself up.

Since most of the members of this group are found in limestones, they appear, upon the whole, to be of less ancient date than the members of the previous group; the oldest forms are those from the limestones of the lower Silurian system, as are also the genera *Ampyx*, *Asaphus*, and *Illænus*, taking them in their correct limits; some peculiar species are also said to have been found in Tafel-schiefer.

Calymene and *Phacops* follow next, but the different species range through all the stages of the Silurian formation. Certain genera furnished with nine or ten body rings and a highly convex axis, are, however, decidedly more modern, and seem to form the last link in the series of creation of these forms. With regard to the division of this very natural group into subordinate genera there appears to be one fact which has hitherto always been overlooked; namely, the nature of the shell. I have already alluded to this, and have shown, when treating of general considerations, that many Trilobites which now appear to us to be smooth, were furnished during life with a peculiar granulated layer; that others, on the other hand, had a peculiar sculpture and punctation in the shell itself, which is incompatible with the presence of a special upper membrane. Pursuing this idea, we discover that Trilobites with distinct granulations always possess a more than ten-jointed axis of the body, which in that case contracts very much posteriorly; the Trilobites without granulation, on the other hand, never have more, and usually exhibit less than ten joints, of equal width in the body. Hence I believe myself justified in assuming that all Trilobites, furnished with an axis of ten joints which gradually becomes smaller towards the posterior part, possessed a granulated upper membrane, while those furnished with a fewer number of joints possessed a truly punctated or sculptured shell. There are, however, in both groups, genera in which the number of joints is ten.

This difference becomes yet more marked when we consider that the Trilobites not granulated occur only in the most ancient and the newest Palæozoic strata, while those, on the other hand, which are granulated, are found in the middle beds of that series. I have employed this structure as a permanent principle of classification,* and thus form two subdivisions of Trilobites having the power of rolling themselves up.

* Dr. Beyrich has questioned the value of this distinction, because in the genus *Bronteus* some species have a granulated, and others a lineated surface of the shell. But this genus belongs to the group of Trilobites not rolling themselves up, and does not therefore affect the question with regard to the other group in which we make use of the principle. A more important objection would appear to be, that certain species of *Archegonus* or *Phillipsia* are granulated, and others lineated, since these genera do roll themselves up. It seems that in this genus, the last effort of a once numerous group, the character in question has degenerated into a mere specific distinction, although once distinctive of the main divisions of the genera.

SECTION.

*Trilobites having the power of rolling themselves into a ball, with the axis of the body contracted posteriorly, the shell granulated, and generally more than ten body rings.** CALYMENIDÆ.

This natural section I formerly subdivided according to the number of body rings into three genera, having respectively thirteen joints, eleven joints, and ten joints. There have since, however, been found forms which render this method of grouping unadvisable, and I now prefer taking the course of the facial suture as the basis of arrangement.

A.

Trilobites capable of rolling themselves up, and whose facial suture terminates exactly in the angles of the cephalic shield.

It appears that there are but two genera that can be included in this subdivision, and for these I retain the names of *Calymene* and *Homalonotus*. They are distinguished from one another by the cephalic shield, which in *Calymene* is furnished with a reflexed margin, over which the anterior extremity of the facial line extends; whilst a flat expanded margin is found in *Homalonotus*, the anterior ends of the facial line meeting in the centre of the margin of the forehead, before the glabella. Other differences accompany this principal one, and justify the separation of the genera.

Genus II.—CALYMENE, Brongniart,† (AMPHION and ZETHUS, Pander).

Cephalic shield semilunate, rather strongly convex, furnished with a margin which is reflected all round, the largest and anterior division usually broken off. The glabella, which is always rather contracted towards the anterior part, has a high, much reflected margin of articulation, and besides this always two or three sulcations at each side, by which it is divided into three or four lobes. If only two sulcations are present, then it is the anterior one which is wanting. The hindermost lobe of each side is the largest, and considerably arched; the second from the posterior extremity is next in point of magnitude; the third is usually the smallest, and frequently very imperfectly separated from the last or anterior one, especially in the most common species, *C. Blumenbachii*. The cheeks extend by the side of the glabella as independent convex plates, and bear strongly projecting but not very large eyes, the horny membrane of which is either wanting or pressed in. They are placed sometimes on the centre (*C. Blumenbachii*), sometimes on the anterior half of

* As additional characteristics, it may be stated that the members of this group always exhibit a highly arched caudal axis, with distinct rings and radiated lateral furrows proceeding from it. These furrows are absent, if not in both, at least in the second group of the second division. The glabella likewise has (with only two exceptions) lateral furrows and lobes.

† If Murchison's figure of *C. variolaris* (*Sil. Syst.* Pl. XIV, Fig. 1) be correct, the animal had thirteen body rings, and belongs to this division. Preceding authors, as Parkinson (*Org. Rem.* iii, Pl. XVII, Fig. 16) and Brongniart (*Cr. fos.* Pl. I, Fig. 3,) enumerate only eleven, indicating an affinity with *Phacops*.

the cheeks, and are in that case either more or less pushed inwards (*C. Tristani*) or outwards. The facial line projects forwards at the level of the eyes over the anterior margin of the head; it is, however, connected at the side of the latter, which is turned under or anteriorly downwards by a diagonal suture running parallel with the margin itself, with its neighbour at the other side. From the point where both enter over the margin, they run almost parallel with each other towards the eye, form over it the covering plate, and turn from its posterior boundary in an S-shaped diagonal direction over the sides of the cheeks, continuing their course towards the posterior corner of the cephalic shield, which they divide exactly in its angle. The cheek-shield thereby assumes a narrow form, which is obtuse at the anterior, and pointed at the posterior part. The posterior angle of the cephalic shield is always obtuse, rounded, and not projecting.

The thirteen body rings have a very convex axis, the separate members of which are very convex; they become gradually more narrow towards the posterior part. The lateral lobes are abruptly separated from the axis, are very convex, and their oblique impression is very strong, but short.

The caudal shield is always narrower, but sometimes longer than the cephalic shield, and is embraced during the doubling-up process by the reflexed margin of the latter; it has a distinct, prominent, seven, nine, or eleven-jointed axis, which is narrowed towards the posterior part, and rounded, and has the same number of lateral protuberances, or perhaps one less, which from the centre appear to be furcated. The free margin of the cephalic shield is only slightly enlarged.

The upper side of the whole of the back was covered during life with a tolerably strong, unequally granulated, membrane, which in well preserved individuals can still be seen quite distinctly; it is, however, more frequently absent. The granulation appears to have been most distinct on the cephalic shield, and on the axis of the body.

Species are found in clayslate (*Calymene Tristani*), in the very oldest limestones (*C. polytoma*, Dalm.), and in the whole Silurian system to its uppermost strata. The most common species, *C. Blumenbachii*, has a very wide range, and is found in Europe, in South Africa, and North America.

1. *C. Tristani*: Limbo scuto cephalici antico valde reflexo, integro, oculis altissimis internis; tubereulo capitis utrinque quadrilobato. Long. 2-3.″ Table II, Figs. 7, 8.

Ref.—Tristan, *Journ. des. Mines.* tom. xxiii, page 21. Brongn. *Cr. foss.* 12. Pl. I, Fig. 2, A-K. Schloth. *Nachtr.* ii, 14. 2. 23. 2 and 40, Tab. XXII, Fig. 5. Dalm. *Palæad* 62. 3. Emmr. *Dissert.* 39. 4. Milne Edw. *Crust.* iii, 320. 5. *Zethus verrucosus*, Pander, *Beitr. etc.* 139, Tab. IV, C, Fig. 4, and Tab. V, Fig. 6.

Cephalic shield strongly granulated when the shell is well preserved; furnished with tubercles, or smooth; the glabella contracted anteriorly, with an extremity which is rather straightly truncated and slightly curved; at each side there are three distinct furrows, which divide it into four almost equal lobes, becoming somewhat narrower towards the anterior part; the lateral portions are very convex; the eyes are placed close to the glabella, and affixed beside the second lobe; the enlarged margin of the head is remarkably prominent, the centre of the anterior margin is erected or reflexed, the lateral lobes, on the

other hand, are more strongly turned downwards; when the animal is rolled up they embrace the caudal shield, so that the latter fits into the wide gap between them and the raised-up centre. The rings of the back are highly arched, but without peculiarities in other respects. Caudal shield oblong, triangular, the extremity prominent, and projecting considerably beyond the axis; the latter seven-jointed, and furnished with an indistinct terminal joint; the sides furnished with elevated, radial protuberances, which are furcated as far as beyond the centre.

Locality.—The clayslate of Angers (*Berl. Mus.*), Nantes, the Cotentin. Found also at Valognes and Cherbourg; in the transition limestone of Esthonia, near Revel, and Zarskoe Selo, also in boulders (*Collection at Halle*).

Remarks.—1. There is no doubt whatever that *Zethus verrucosus* of Pander is identical with *Calymene Tristani*; the structure of the glabella is quite the same.

2. The caudal shield represented by Schlotheim (*ante cit.*) probably belongs to this species.

2. *C. Polytoma:* Limbo scuti cephalici antico crenato; tuberculo capitis antice latiori, in apice quadrilobato. Long. 2-3.″

Ref.—Dalm. *Palæad.* 37, Tab. I, Fig. 1, *a-c.* Emmr. *Dissert.* 38. 2. Milne Edw. *Crust.* iii, 321. 6. L. v. Buch, *Beitr.* 45. *Asaphus Fischeri*, Eichwald, *Dissert.* 52, § 58. Tab. III, Fig. 2, *a. b. Calymene frontiloba*, Stschegloff. *Amphion frontiloba*, Pander. *Beitr.* 139, Tab. IV, Fig. 1; Tab. IV, B, Figs. 5, 6, 7; Tab. V, Figs. 3, *a*, *b*, and 8.

Cephalic shield less convex than in the preceding species, and the lateral lobes less turned downwards; the glabella broader towards the anterior part, furnished with two lateral sulcations, dividing it into three lobes, that are broader anteriorly; between the two anterior lobes there are three radiating furrows directed towards the centre of the head, which separate two smaller central lobes from the external ones. The enlarged border at the anterior margin is divided by eight furrows into nine rather acute notches or teeth, which very readily break off, and are therefore wanting in many specimens. Eyes of a moderate size, placed in the line of the posterior lateral sulcation, projecting very far outwards, and inclosed by the indented facial line. Beneath them there seems to be another marginal concentric furrow. Body rings strongly arched, rather short. Caudal shield long, trilateral, rather acuminate; the axis many-jointed (eleven-jointed according to Dalman's figure and Eichwald's enumeration), and reaches almost as far as the end; the lateral folds probably not furcated (at least the figures indicate no such division).

Loc.—The red transition limestone of East Gothland and Esthonia; I have not myself seen a specimen.

Remark.—The specimen represented by Dalman was deficient in the margin of the head, and so also was that figured by Pander, Table V, B, Fig. 3. The presence of this notched margin, and the somewhat different structure of the glabella, scarcely justify the constitution of a peculiar genus, as suggested by Pander (who, however, seems to think his species different from Dalman's). His enumeration of the body rings (twenty in the body, four in the tail) is erroneous; Eichwald had already enumerated them correctly.

3. *C. Blumenbachii:* Limbo scuti cephalici antico integro; tuberculo capitis subquadrilobo antico sive ultimo maxima, penultimo appendiculato. Long. 1¼-3″. Table II, Figs. 1-3.

Ref.—Ch. Lyttelton, *Phil. Trans.* vol. xlvi, p. 598. Pl. I. II C. Mortimer,

ibid. 600. Em. Mendez da Costa, *Phil. Trans.* vol. xlviii, p. 286. I. Torrubia, *App. P. L. Hist. N. Espan.* pp. 83, 13, *n.* 96, Com. iii, *n.* 4. Guettard, *Mém. de l'Acad. Roy. des Sci.* tom. xv, Pl. IX (VII), Fig. 2. Wilkens, *Stralsund Magaz.* i, 4, Tab. I, Figs. A-2. Klein, *Spec. Descr. petref. Gedan.* Tab. XV, Figs. 5-7. J. J. Walch, *Text zu Knorrs Abbild. d. Verstein*, vol. iii, p. 222, Tab. IX, Figs. 1-5. Beckmann, *Nov. Comm. Soc. Reg. Göttingen*, tom. iii, pp. 101-2. *Tril. tuberculatus*, Brünnich, *Nya. Saml. etc.* i, 389. 1. Gehler, *Progr. &c.* 6. Figs. I-V. Blumenbach, *Abbild. natuch. Gegenst.* i, Tab. L. *Entom. paradoxus*, Parkinson, *Org. Rem.* iii, Pl. XVII, Figs. 11, 13, 14. Schlotheim, *Petref.* p. 39. 2. Wahlenberg, *N. A. Ups.* viii, 31. 6. *Ent. tuberculatus*, *Calymene Blumenbachii*, Brongn. *Cr. foss.* 11. 1. Pl. I, Fig. 8, A-C. Schloth. *Nachtr.* ii, 13. 1. and 33. 1. Dalm. *Palæad.* 35. 1, Tab. I, Figs. 2. 3. *a-c.* Payton, *Tril. of Dudley*, Fig. 14. *Cal. Blumenb.* Green, *Mon.* 28. Klöden, *Verst. d. Mark Brand.* 105. Harlan, *Med. and Phys. Research.* 300. Murchison, *Silur. Syst.* ii, 653. Pl. VII, Figs. 5-7. Buckland, *Bridg. Tr.* p. 46. Figs. 1-3. Bronn, *Lethæa*, i, 110. 99, Tab. IX, Fig. 3. Hisinger, *Leth. Suec.* 10, Tab. I. Figs. 3-4. Boeck, *Gaea. Norw.* i, *no.* 16. Quenstedt, *Weigmann's Archiv*, 1835, i, 342. Emmr. *Dissert.* 39. 3. L. v. Buch, *Beitr. z. Geog. Russland*, 47. Milne Edwards, *Crust.* iii, 318, 1.

Cephalic shield lunate, the margin strongly reflexed but simple, thickened beneath: glabella indistinctly four-lobed, the first anterior lobe larger than the second, which is not so much separated from it as from the third; the latter highly convex, but smaller than the fourth and posterior one. Eyes at the centre of the cheeks, not very prominent, placed on a line with the third lobe; posterior margin of articulation much more narrow than the lobe preceding it. Thirteen rings in the body, which become successively smaller, without presenting any peculiarities. Caudal shield considerably smaller than the cephalic shield, the axis short, broad, seven-jointed, the two last joints indistinctly separated, the sides furnished with six radiating furrows, with intermediate ones along the whole length of the four central ones. The whole surface finely granulated in well-preserved fragments (var. *pulchella*, Dalman, *l. c.* Fig. 3), but more generally smooth, owing to the uppermost layer of the shell being absent.

Remarks.—1. I have compared all the authors quoted, as far as they were accessible to me, and convinced myself that they all treat of this species. The figures of Brongniart marked A, B, and of Murchison, are the only ones sufficiently accurate; in all the others the boundaries between tail and body cannot be recognized with sufficient distinctness. Dalman's figure with ten body rings is erroneous, and as erroneously copied by Hisinger.

2. *Zethus verrucosus* of Pander, which M. v. Buch considers as belonging to this species, I have preferred enumerating under *Cal. Tristani*; his *Z. uniplicatus* (Beitrage z. Geogn. d. Russ. Reus. 138, Tab. V, Fig. 7), with which the representation of Razoumowsky (Ann. Sc. Nat. viii, Pl. XXVIII, Fig. 4) seems to correspond, has as little relation to this species. The glabella differs too much in both figures to permit of their being referred to *Calymene Blumenbachii*, even supposing it to have been imperfect in the specimens that were examined by the authors cited. The species must therefore be regarded as distinct.

3. *C. platys*, Green, *Mon.* 32, Milne Edw. *Cr. l. c.* 320. 4, I take to be a large specimen of *C. Blumenbachii*, with perfect granulations.

4. The numerous references above given sufficiently prove that this species is widely extended; it is, however, only found in limestones,* and if its relation in this respect in England can be assumed

* Not so in England.—Editors.

as general, it belongs especially to the upper and middle Silurian strata (*Ludlow, Dudley, Wenlock*). In Sweden it is only found in the limestone of Gothland, which is wanting in Esthonia. In Germany it seems to occur in only travelled fragments, and appears to have been transported from the Scandinavian mountains. Torrubia found it in Spain, on the frontier of Pardos, two leagues from Molina de Arragon. In North America it is found in different places, especially near Lebanon, in the state of Ohio, and at Trenton Falls, in New York. Murchison also mentions specimens from the Cedar Mountain at the Cape of Good Hope.

4. *C. callicephala:* Limbo scuti cephalici inerassato, oculis altis externis, marginem superantibus; tubereulo capitis utrinque trilobo: lobis posticum versus majoribus. Long. 2½. Table 11, Figs. 9-10.

Ref.—Green, *Mon.* 30. Milne Edw. *Crust.* iii, 319. 2.

More nearly allied to the preceding species in habit, but the cephalic shield is comparatively shorter and broader, the sides more strongly curved, the posterior angles more turned backwards. The reflexed margin is not very strong, at least not at the anterior part, where it is usually highest. The eyes are rather small, but are remarkably prominent, so that they project from above over the external margin of the shield; they are situated at the anterior part beside the front lobe of the glabella. This lobe is small and very narrow; the second certainly less broad, but projecting more outwards; the third is remarkably broad, large, semicircular, and separated for the greater part not only from the preceding lobe, but also from the axis of the head by a furrow (as in *Cal. Tristani*). I have not seen the body and tail; according to Green, the two together consist of fourteen rings, in which case only one would belong to the tail; the axis of the latter is almost of equal breadth, therefore very obtuse at the posterior part, and the lateral lobes are not furcated.

Loc.—In North America, it occurs in Hampshire, Virginia; on the shores of the Miamis, at Cincinnati; and in Indiana; in a blackish gray limestone. This species is not found at Trenton Falls, where *Cal. Blumenbachii* is so frequent. I saw a plaster cast of the head (No 2, Green) in the Berlin Natural History Cabinet.

Remarks.—The other species, considered as belonging to *Calymene*, are arranged by me under other groups.

1. *Cal. bellatula.* Dalm., and *Cal. concinna*, Dalm., are the representatives of two particular genera; *C. actinura.* has been already mentioned (p. 69) and *C. sclerops* is a *Phacops.* Of *C. punctata*, I know only the caudal shield; it forms according to Boeck (Gaea Norweg. 13) a particular genus, including also *Cal. variolaris.*

2. I can give the following explanations respecting Green's various species: of *C. seleneeephala* (p. 31; Milne Edw. 320, 3; Emmr. *Diss.* 40, 6) I have seen a plaster cast (No 3 of Green), but owing to the badly preserved state of the specimen from which it had been taken, I could not arrive at any sure specific characters. *C. microps*, Green (p. 34, Model 6), is a *Phacops*, and will be alluded to more particularly under this genus. *C. anchiops* (p. 35, Model 7) likewise belongs to the genus *Phacops*, but not *C. diops*, which forms a separate genus with *Cal. concinna*, Dalm. *C. macrophthalma* (p. 39) is a *Phacops*, and *C. Bufo* (p. 41) likewise. *C. odontocephala* (Gr. Suppl. p. 9, Milne Edw. 322, 8) is likewise a *Phacops*, but a distinct species.

3. Murchison's *Calym. Darwinigiæ* (*Sil. Syst.* ii, 655, Pl. XIV, Fig 3) and *Cal. tuberculata* (*l. c.* Fig. 4) belong to *Phacops;* his Fig. 5, Pl. XIV, is perhaps the caudal shield of a species of the latter genus, and in that case is identical with *Ph. latifrons*, to which *C. tuberculata* decidedly belongs.*

4. Milne Edwards's species (pp. 318-328) have been already explained, with the exception of *Cal. Stokesii* (p. 324, No. 13), (not *Asaph. Stokesii* of Murchison—*Sil. Syst.* Pl. XIV, Fig. 6), which is my *Phacops latifrons.*

* The figure referred to represents the tail of a *Proetus.*—Editors.

Genus 12.—HOMALONOTUS, König, (TRIMERUS, Green, Murchison; DIPLEURA, Green.)

Cephalic shield hyperbolic, the anterior angle rather acute, the lateral margins gently arched, the posterior margin tolerably straight, without the angles being extended backwards; the whole upper surface gently arched, but the region at the external margin and the border at the posterior margin rather flatly expanded; the latter separated by a furrow, slightly arched. The glabella undivided, broader towards the posterior than at the anterior part, and occupying about two thirds of the posterior margin. It then contracts a little, and assumes a round shape towards the anterior part; without lateral lobes and sutures, but there is a trace of a furrow, which issued from the region where the eyes are situated beside the glabella. This furrow is produced backwards towards the central line, and may sometimes be perceived with tolerable distinctness. Both furrows correspond with the posterior furrows of the glabella of the preceding genus, and separate the anterior cerebral region, the forehead, from the posterior or branchial region.

Eyes placed near the centre of the glabella, just in the centre of the lateral parts of the shield, or a little behind it, depressed, comparatively smaller than in *Calymene*; usually similarly excavated.

Facial suture parallel anteriorly with the margin of the cephalic shield, but apart from the latter; acutely angular, terminating on the flat extension of the cephalic shield; thence turning in the form of an arch towards the eye, over which it forms the well-known covering plate, and then bends itself with an S-shaped curvature towards the posterior lateral angle, which is divided into two halves, either in the angle itself, or before the point towards the outer side.

Axis of the body thirteen-jointed, decidedly narrower towards the posterior part; the axis itself but slightly arched, owing to which the lateral lobes (the transverse diameter of which is smaller than the transverse diameter of the axis) are not as strongly separated from it as usual; the posterior margin of each separate ring of the axis is produced forwards, acutely angular, sometimes (in *Dipleura*) even rather turned up; the anterior or articular portion separated by a more or less impressed transverse furrow, proceeding from the posterior part of the ring. This character does not belong to any other genus of the Trilobites, and on that account appears to me a most important and peculiar one.*

Caudal shield hyperbolic, longer, but much more narrow than the cephalic shield, and

* In interpreting the fragments of this genus, we ought to be very particular in observing whether the impressions of the rings originate from the upper exposed surface of the back, or from the inner surface, which is turned towards the soft part of the animal. In the former case the transverse furrow, which separates the articulating portion from the ring itself, appears as a fine line, and thus it has also been represented in Murchison's Figures (Tables VII and VIII, as far as Figs. 1, 2); in the latter it forms a deep broad furrow, which originates from a horny process of the ring that hangs downwards towards the inner part, and owing to this process being thick, it is also broadly and deeply impressed into the matter inclosing it. Thus appear Murchison's Figures 3 and 4 in Table VII. Hence it follows that impressions differing from each other in the manner described do not indicate different species, but different sides of the shell of the same species. My Figures, Table IV, Figs. 10 and 11, show the difference in the rings of the shells of *Homalonotus* and *Calymene* more particularly, and respecting their significance I refer the reader to the explanations of the plates.

proportionably smaller; its axis has either no articulation at all, or a distinct one, very rapidly narrowed posteriorly and even at the commencement rather narrower than the last ring of the body; the external terminal angle more or less prominent.

Remark.—The species of this genus are amongst the largest, but also the rarest Trilobites, and seem to be peculiar to the upper or central Silurian strata. I regret to say that I have only been able to examine casts or imperfect specimens. I recognized the granulation, however, in both most distinctly, where there were any remains of shell; the specimens deficient in shell, on the other hand, always appear quite smooth. According to the proportion of axis and lateral lobes, they furnish us with two subdivisions, which most authors enumerate as distinct genera.

A. *Diplenra*, Green.—The outer end of the facial suture cuts in half the posterior angle itself. The joints of the axis are not broader than the lateral lobes, and very distinctly separated from the latter; the latter have a process at the lower and outer extremity, with which they passed beneath the open margin of the cephalic shield during the rolling-up process. The posterior margin of each ring of the axis is strongly reflexed, and the ring in itself alone is highly arched.

Caudal shield slightly pointed or produced forwards, the axis without joints, the sides even and ribless.

1. *H. Decaji*: Scuto capitis dilatato, dimidio latitudine vix longiori; oculis ellipticis; annulis trunci convexis, in margine postico reflexo dilatatis. Long. $2^1/_2$".

Ref.—*Diplenra Dekayi*, Green, *Mon.* 79, Figs. 8, 9. Bronn, *Lethaea*, i, 113. 101, Plate IX, Figs. 6, 7. Harlan, *Med. and Phys. Research.* 304. Emmr. *Diss.* 42, IV. Milne Edw. *Crust.* iii, 316. Bronn, *Leonh. and Br. Jahrbüch.* 1840, pp. 447 et seq.

Found in different parts of North America; amongst other places at Lockport, Madison, Steuben, Cazenovia, Rochester, all situated in the state of New York; also at Northumberland, in Pennsylvania, and Mount Hope, in the vicinity of Baltimore. I have only had an opportunity of examining the two plaster casts (Nos. 30 and 31) of Green's fragments, and cannot therefore give an accurate description. The distinct granulation and the acute margins of the body rings render it certain that the calcareous shell remained in the actual specimens, which fact agrees very well with the absence of joints at the caudal axis. These joints are probably wanting only at the upper surface, and are visible on the inner surface, as is shown by the smooth individuals without a calcareous shell. Green's statement of there being fourteen rings is based upon an error, as the models have only thirteen; for that which appears to be the first, is the thickened posterior margin of the cephalic shield.

B. *Trimerus*.—The outer extremity of the facial suture meets the margin rather before the angle of the cephalic shield, externally. The joints of the axis are broader than the lateral lobes, very slightly separated from the latter, and not reflexed at the posterior margin; a distinct transverse furrow, which also continues over the anterior surface of the lateral lobes, divides the margin of articulation from the true ring.

Caudal shield very prominent at the end, the axis distinctly jointed, the sides furnished with ribs.

A.—Species without spines and tubercles. TRIMERUS, Green; HOMALONOTUS, König.

2. *H. Knightii:* Scuto candæ acuminato, annulis rhachis 8-9, costis lateralibus 6. Long. corp. 3-4″.

Ref.—KÖNIG, *Icones Sectil.* i, 4, Plate VII, Fig. 85. BRONN, *Lethæa.* i, 119. 107, Table IX, Fig. 14. MURCHIS. *Sil. Syst.* ii, 651, Plate VII, Figs. 1, 2. MILNE EDW. *Cr.* iii, 315. *Homalon. Ludensis,* MURCH. ibid. Figs. 3, 4. EMMR. *Dissert.* 41. 8. BRONN, *Leonh. Jahrb.* 1840, 445.

Found in the grauwacke strata of the Eifel at Daun (according to specimens in Sack's collection), and in the upper Silurian strata of England.

I have examined only two caudal shields of this species; they are comparatively shorter and broader than that of the following species, the axis is more flatly arched, and more distinctly pointed at the end, owing to a furrow which surrounds it. We can recognize in it seven distinct rings, besides the margin of articulation; there is also an eighth, and indeed, even a ninth ring, but very slightly marked; after which follows the short triangular pointed extremity. There are six strong broad ribs on the sides. The point of the shield is broken off in the specimen, but it must have been prominent.

3. *H. delphinocephalus:* Scuto caudæ acuminato, in apice reflexo, annulis rhachis 11-12, costis lateralibus 8. Long. corp. 3-6″.

Ref.—*Trim. delph.* GREEN, *Mon.* 82, Fig. 1 (Model, No. 32). EMMR. *Dissert.* 41. 7. BRONN, *Lethæa,* i, 112. 100, Table IX, Fig. 5. *Homalon. delphino-cephalus,* MURCH. *Sil. Syst.* ii, 651, Plate VII, to Figs. 1, 2. MILNE EDW. *Crust.* iii, 314. 1. *Homalo. Ahrendi,* ROMER. *Verst. des Harzes,* 39. 1, Tab. XI, Fig. 5.

Found in a yellow grauwacke from the Eifel, containing a considerable quantity of iron (according to specimens in Sack's collection); also in the transition limestone of North America (Williamsville, Niagara, New York), and of England (Wenlock, Dudley).

The rich collection of Mr. Sack contains perhaps a dozen caudal shields of different size (varying from half an inch to two inches in length), besides fragments of all parts of the head, and some joints of the body, all belonging to this species. They correspond in the principal points with Murchison's very accurate figure. The caudal shield, which appears to me to present the best specific character, is comparatively shorter, more acutely triangular, very prominently pointed at the end, and is here rather flatly extended. The axis is certainly more convex, but not so strictly defined as in the preceding species; its rings are decidedly shorter but higher, and separately, with a much sharper edge. I have counted eleven distinct rings, and a very indistinct twelfth ring, besides the margin of articulation; eight equally distinct ribs are perceptible on the sides, which are situated less towards the external part, and more posteriorly.

B.—Species with thick, symmetrical spines on the whole surface of the back.

HOMALONOTUS, Murch.

4. *H. armatus:* Tuberculo capitis octies spinoso, lateribus scuti cephalici bispinosis; annulis trunci bispinosis, rhachi caudæ mutica. Long. corp. 3-6″.

Ref.—H. Greenii, GOLDF. *in Bronn u. Jahbr.* 1843. 560. 5.

Found in the grauwacke strata of the Eifel at Daun. The collection already alluded to contains some fragments of this species, from which I have constituted it, and which I shall now describe more particularly. It is comparatively broader than the other species, the cephalic shield is hyperbolic, slightly reflexed at the circumference; the glabella is furnished with eight spines, namely, six larger ones in two rows, three on each side, and two smaller ones close to each other, in the centre before the two posterior ones. The cheek-shield has a large high spine at the sides, and rather behind the eyes; besides this there is one spine at each side, on the elevated part of the posterior margin, and one on its centre. The body rings are each armed with two spines, one at each side, immediately before the front, where they become transformed into the lateral lobes.

Caudal shield short and small, the axis six-jointed, unarmed; each of the sides furnished with three ribs, of which the first bears a spine at each side; the end of the shield is oblong pointed, in the form of a spine.

5. *H. Herschelii:* Annulis trunci quadrispinosis, lobis lateralibus unispinosis; rhachi caudæ in basi 4 spinosa, lateribus muticis.

Ref.—MURCHIS. *Sil. Syst.* ii, 652, Plate VII, to Fig. 2. MILNE EDW. *Crust.* iii, 315.

Found in the upper Silurian strata of the Cedar Mountains, Cape of Good Hope, associated with *Cal. Blumenbachii* and *C. Tristani* (?).

According to Murchison's figure, the caudal axis of this species consists of fourteen joints, the two first bearing a spine at each side; the sides seem to possess a number of ribs equal to the number of joints, but no spines. Of the body rings we find seven; they appear to be furnished with four spines, two on each side, approximating to the lateral lobes; and besides these there is probably another one on the lateral lobes themselves.

The cephalic shield is wanting.

B.

Trilobites having the power of rolling themselves up, whose facial suture terminates in the external lateral margin of the cephalic shield.

This section of Trilobites, originally established by Quenstedt, and confirmed by Emmerich, includes only the genus *Phacops*, and appears not to require the generic subdivisions proposed by Milne Edwards and Goldfuss.

Genus 13.—PHACOPS, Emmerich. (CALYMENE, *Auctorum;* PLEURACANTHUS, and PELTURA, Milne Edw.; ASAPHUS, ACASTE, and PHACOPS, Goldfuss.)

Cephalic shield semicircular, or somewhat parabolic (when the posterior angles strongly project); lunate; acutely angular, or rather extended at the external margin, and thickened at the posterior margin; the glabella highly convex, in some simple, in others divided into several lobes by lateral sections; always broader at the anterior than at the posterior part, and at the latter, broader than, or as broad as the distance of both eyes from each other. The facial suture extends in a circle, concentric with the posterior margin, round the glabella, turns towards the eye, forms the covering plate, and then runs in an S-shaped curve from the posterior corner of the eye to the lateral margin, which it divides at a considerable distance in advance of the posterior angle.

Eyes remarkably large, very prominent, forming a segment of a cone, and having large semicircular lenses in considerable but varied number. Posterior angles of the cephalic shield either obtuse, or longitudinally extended.

Body rings always eleven, the axis rather smaller than the lateral lobes, both separately convex, the extremities of the latter either rounded off, or pointed in the shape of a spine; the joints of the axis distinctly contracted towards the posterior part.

Caudal shield partly obtuse, partly acute, parabolic, the axis distinctly jointed; the sides strongly ribbed.

The upper surface in all well-preserved individuals is granulated, but is smooth in those which have lost their natural shell; the body rings also are frequently smoothed by friction, even when the shell is present.

GROUP A.—Species with a simple, undivided, trapezoidal glabella, which at the posterior part is provided with a short peduncle, and has beside it two small tubercles. Angles of the head obtuse, the caudal shield rounded at the end.

1. *Ph. latifrons:* Lateribus tuberculi capitis rectis; rhachi caudæ 7-9 annulata, costis lateribus 5-7. Long. 1-3″. Table II, Figs. 4-6.

Ref.—*Calymene macrophthalma,* BRONGN. *Crust. foss.* Pl. I, Fig. 5, A-C. SCHLOTH. *Petref. Nachtr.* ii, 15. 34. KNORR and WALCH, *Naturgeschichte der Verstein.* Suppl. Table 1, Figs. 4, 5. ZENO, *Neue Phys. Bell.* Table 1, Fig. 2. HÖNINGHAUS, *Nöggerath's Rheinb. und Westph.* 291, with figures. The same author, in the *Isis,* 1824, pp. 464, 534, 986; Table V, Figs. 1, 4. and 1830. 95. Table I, Fig. 2, *a. c.* COUNT STERNBERG, *Verh. d. Vaterl. Mus.* 1825. 75. 1, Table I, Fig. 1, A, D. DALM. *Palæad.* 63. 8. BRONN, *Leth.* i. 111. 2, Table IX, Fig. 4, *a. b.* GREEN, *Mon. of Trilob.* 39. MURCHISON, *Sil. Syst.* ii, 655, Pl. XIV, Fig. 2. BUCKL. *Bridg. Tr.* Pl. XLVI, Fig. 4. EMMERICH, *Dissert.* 19. 1. *Cal. latifrons* and *Schlotheimii,* BRONN, *Leonh. Zeitschr. f. d. Miner.* 1825. 317, Table II, Figs. 1-8. DALM. *Palæad.* 64. 10. 11. RÖMER, *Rhein.* 81. 68. *Cal. bufo,* GREEN, *Mon. of*

Tril. 41. MILNE EDWARDS, *Crust.* iii. 327. 19. *Cal. tuberculata*, MURCH. ii. 656, Pl. 14, Fig. 4. MILNE EDW. *Crust.* iii, 325. 14. PORTLOCK, *Rep.* 284, Pl. II, Fig. 10. *Cal. granulata*, COUNT v. MÜNSTER, *Beitr.* iii, 36. 3, Tab. V, Fig. 3, *a-d*, and *Cal. lævis*, ibid. Fig. 4. *Cal. Stokesii*, MILNE EDW. *Crust.* iii, 324. 13 *Trinucleus* (?) *lævis*, COUNT v. MÜNSTER, *Beiträge*, N. 116. 1, Tab. X, Fig. 6. (?) *Cal. Jordani*, ROMER, *Verst d. Harz.* 37. 1. Pl. XI, Fig. 4.

Loc.—The transition limestone of the Eifel, the Hartz, the Fichtelgebirge, Bohemia, England, and North America.

This common Trilobite is rarely well and perfectly preserved, hence the many designations that have been given to it. Perfect specimens with the shell are always strongly granulated, as I have represented it. The granulation is most distinct on the glabella and on the eyelids less so on the body-rings, and slighter everywhere on the sides, where indeed it is usually altogether wanting. It is likewise not seen when the true shell is absent. Brongniart, Bronn, and Murchison have figured such individuals as the normal state. The axis of the tail, in specimens without a shell, has only seven rings and five ribs; two more rings and ribs are seen when the shell is present, but the two latter are very slightly marked, and sometimes can scarcely be recognized. The eye, according to an accurate calculation, has from 99 to 104 lenses, many of which are frequently wanting in the centre at the upper margin in some individuals, but are present in others. There are five lenses at the anterior part, and two at the posterior, in the first row; the rows then increase at each side by from one to five lenses in the vertical row, upon which rows of six and seven lenses alternate several times with one another; there are usually from sixteen to eighteen of such rows forming each eye.

Remarks.—1. Brongniart described as *Cal. macrophthalma* a species quite different from this, with a glabella divided in lobes; and not only has the present species, but also the *C. macrophthalma* of later authors, been described as belonging to various individuals resembling his species. The latter, however, is much more common than the former or Brongniart's, and has been almost always mistaken for it, although totally distinct. Höninghaus and the naturalists of Bonn seem afterwards to have repeated the error committed by Brongniart himself, and Count Sternberg followed in their footsteps. Bronn, who at first correctly considered his *Cal. Schlotheimii* and *C. latifrons* as different, subsequently returned to the error of his predecessors. Murchison and Emmerich recognized the difference of fig 5 and fig. 4 of Brongniart's representation, but suffered the name erroneously given by Brongniart to remain, as referring to the really undescribed figure marked 5. Milne Edwards was the first who announced Brongniart's error (*Crust.* iii, 323, note 2), and who restored its original name to *C. macrophthalma*, although the introduction of a new name for the second species was superfluous, since it had already received two from Bronn. I therefore retain the name originally given by this careful investigator.

2. In the first and second chapter, I have mentioned the species here described as *Ph. latifrons* under the name of *Phacops macrophthalmus*, not choosing to differ from the prevailing custom, and I therefore called the species as it had hitherto usually been called. This, however, must not be done for the future.

2. *Ph. protuberans*: Lateribus tuberculi capitis subangulatis sive arcuatis; oculis minutis, externis. Long. 2″. Table III, Fig. 6.

Ref.—EMMR. *Dissert.* 19. 2. STERNB. *Verh. d. Vaterl. Mus.* 1825. 77, Tab. I, Fig. 2, *a. c. Cal. protub.* DALM. *Palaad.* 63. 9.

Loc.—A gray limestone of the Branikberg, near Prague, (Nos 2. 18 of the Berlin Museum). It is said by Count Sternberg to occur also in Westphalia.

This species approximates very nearly to the preceding, but can be readily distinguished from it. The glabella, which in other respects is similar, is not quite so broad at the anterior part as in *Ph. latifrons*, and its sides are rather angular, or at least bent in this, but extend in quite a straight line in the former; the eyes, which are small, are situated beside the anterior part of the angle, close to the margin of the head, and have only few lenses (from two to three rows); the circumference of the cephalic shield is more broadly reflexed, and does not present quite so acute an edge; the posterior margin seems to be less produced. The body and caudal shield are not yet known; the individual which I examined was without a shell, and therefore quite smooth.

Group B. Species with a glabella divided into lobes; the isolated little tubercles on the posterior angles are wanting, and instead of them there is a transverse protuberance.

Remark.—The glabella in this group has always three lateral lobes between the large trapezoidal front lobes and the posterior margin of articulation, therefore four lobes in all (including the anterior and chief protuberance). Of these the third is sometimes very small, and on that account appears occasionally to have been overlooked.

Sub-Group (*a*). The posterior extremity of the caudal shield rounded or obtuse.*

3. *Ph. anchiops*: Tuberculo capitis elevato, lobis lateralibus obsoletis (s. mutilatis); oculis maximis; rhachi caudæ 12 annulata, costis decem. Long. 2-4″.

Ref.—*Calym. anch.* Green, *Mon. of Trilob.* 35, Mod. 7. Emmr. *Dissert.* 22. 8. Milne Edw. *Cr.* iii, 325, 15. *Var. minor. Asaph. Wetherilli*, Green, Mod. 20.

Locality.—In a black limestone of North America, at Ulster and Murron (New York).

The plaster cast which I examined, and which is in the Berlin Museum, reminds one of the preceding species, and the present is principally distinguished by a longer urn-shaped glabella, sulcated posteriorly, in which, however, I could not perceive any distinct lateral lobes, with an acute outline as usual. On the other hand, there is only an imperfect lobe, which is isolated, and projects near the tubercle of the eye at the glabella; and instead of the peduncle, I notice before the margin of articulation a short transverse prominence scarcely disconnected. The original from which the cast had been taken was, however, evidently imperfect. The body has distinctly eleven joints; there are twelve joints of the caudal shield, and ten lateral ribs towards the posterior part, but rather indistinct. Green, owing to this, enumerates only twenty rings in all, which would leave nine for the tail.

Remark.—*Asaph. Wetherilli*, of which I examined a plaster cast at Berlin, appeared to me to be a smaller individual of the species described by Green as *Cal. anchiops*. The head is, however, so indistinct, that accurate determination is impossible; I was able to recognize the eleven body joints with certainty.

* From observations which I have made on *Phacops sclerops* and *P. procerus*, and which I shall subsequently make known more in detail, I believe myself justified in inferring that elongated pointed angles at the cephalic shield existed in most of the species of *Phacops* having a lobed glabella, but were broken off with the calcareous shell. These species therefore can no longer be grouped according to the form of the cephalic shield.

4. *Ph. sclerops:* Protuberantiæ frontalis lobo antico maximo reniformi, lobo quarto minuto, reliquis abrupte angustiori; rhachi caudæ 8 annulata, costis lateralibus sex. Long. 1½-2.″ Table IV, Figs. 5-6.

Ref.—*Calym. sclerops*, Dalm. *Palæad.* 39. 5. Milne Edw. *Crust.* iii, 322. 9. *Phac. sclerops*, Emmr. *Dissert.* 22. 8. Pander, *Beitr.* 138, Tab. XLVIII, Fig. 9, Tab. V, Fig. 4, Tab. VI, Fig. 10.

Loc.—Swedish limestone at Husbyfjöl, in East Gothland; in gray limestone near Skarpasen; in red limestone near Furudal; in Dalecarlia in red limestone.

This distinct species can readily be known by the peculiar form of its glabella, which consists of five lobes, of which the anterior and largest is singularly wide, and projects laterally over the eyes; the second is narrower and posteriorly smaller, the eye corresponds with it; the third is a very small narrow lobe, and the fourth has pretty much the same size as the margin of articulation following it. The eyes are large and prominent, the facial suture is distinct (Dalman was the first who described the facial suture in this species as terminating in the lateral margin); the posterior cephalic angles are obtuse. The axis of the tail consists of four distinct, and four rather more indistinct rings, and has from six to seven lateral ribs; its extremity is obtuse, and so also is the front of the cephalic shield.

Remark.—From examining a great number of specimens, I have had an opportunity of convincing myself that this species does possess long projecting angles at the cephalic shield, and thereby approximates so near to *Ph. conophthalmus* of Boeck, that I am inclined to doubt their specific distinctness.

5. *Ph. conophthalmus:* Protuberantia frontali antice latissima, posticum versus valde coaretata; oculis minutis; rhachi caudæ 7 annulata, costis lateralibus 9. Long. 2½″.

Ref.—Emmr. *Dissert.* 21. 7. Boeck, *Gaea Norw.* i, 4.

Loc.—The yellowish gray limestone of Revel, and Ladegaards Oen at Christiania; found likewise in boulders at Gussow, in Mecklenburg (Berlin Museum).

This singular species resembles the preceding one in the formation of the glabella, but is readily distinguished by the pointed angles of the cephalic shield. The anterior large lobe of the glabella has an oblique rhombic form with rounded angles; the second is obtusely trilateral, rather truncated towards the posterior part; the third is the smallest, and is rather narrower than the margin of articulation which follows it. The eyes, which are not large, correspond merely to the second lobe of the head. The facial suture is very distinct. The cephalic shield, which is very broad at the sides and rounded off at the anterior part, is rendered conspicuous by a sharp point at the posterior extremity, which point is about as long as the four first body rings; the caudal shield has a ten-jointed rounded axis, obtuse at the posterior part, and nine diagonally-furrowed lateral ribs; it is much smaller than the cephalic shield, and not pointed at the end, but perceptibly incurved. When rolled up, this incurvation is closely embraced by the under margin of the cephalic shield.

Remarks—1. The cephalic shield from the transition limestone of Revel, figured by Schlotheim in Leonhard's *Taschenbuch*, 1810, Table I, Fig. 6, I consider as most decidedly belonging to this species.

2. *Calymene microps* (Green, *Mon.* p. 31; Milne Edw. *Crust.* iii, 326. 17) is very nearly allied to the species just described, and may perhaps be the same.

6. *Ph. odontocephalus:* Protuberantia frontali antice ovata, lobo secundo constricto; limbo ante protuberantiam octies dentato. Table IV, Fig. 4.

Ref.—*Calym. odontocephala*, GREEN, *Sill. Am. Journ.* vol. xxv, p. 334. HARLAN, *Med. and Phys. Res.* 301.

Loc.—In a gray sandstone at Ulster, New York, U. S. I saw the plaster cast of a cephalic shield of this species at Berlin.

The glabella is short at its anterior extremity, ovate, moderately convex; the second lobe is reniform, almost isolated, only connected with the central axis by a short peduncle; the third is a narrow transverse protuberance, behind which there follows a fourth broader one, perfectly resembling the margin of articulation. The large eyes correspond with the kidney-shaped prominence; they reach neither to its anterior nor to its posterior extremity, and are far removed from the external margin. A broad flat border encircles the latter, in which may be distinguished anteriorly, and placed in front of the glabella, eight obtuse indentations, inclosed by an impressed furrow (? of the facial suture). The posterior angles of the specimen were indistinct, but appeared to be obtuse; body and caudal shield are wanting.

Sub-group (*b.*) The extremity of the pygidium sharply angulated.

7. *Ph. macrophthalmus:* Lobo antico capitis acutangulo, lobis sequentibus æqualibus; rhachi caudæ 10-12 articulata, scuto in apice acuminato. Long. 1-1½″.

Ref.—*Calymene macr.* BRONGN. *Crust. foss.* 14, Pl. I, Fig. 4, A, B. MILNE EDW. *Crust.* iii, 323. PANDER, *Beitr.* 138, Tab. IV, B, Fig. 8; Tab. V, Fig. 5; Tab. VI, Fig. 9. *C. Downingiæ*, MURCHISON, *Sil. Syst.* ii, 655, Pl. XIV, Fig. 3. BUCKL. *Bridg. Tr.* Pl. XLVI, Fig. 5. MILNE EDWARDS, *Crust.* iii, 324. 12.

Loc.—The older transition limestone of Humandière in Brittany, and in the Petersburg hills.

This species approaches very near to *C. sclerops* in point of habit, but is much more slender; the glabella is similarly four-lobed, and the eyes are much larger, almost as large as in *Ph. rotundifrons*. The anterior lobe of the glabella is obliquely rhombic, rather acutely angular at the anterior part; the three following lobes between it and the margin of articulation become successively rather smaller, and the posterior lobe is the most strongly arched among them. The prominent eyes reach from the anterior margin of the cephalic shield to the posterior. The caudal shield, according to Pander, has from ten to twelve joints in the axis, slight lateral ribs, and a short but acute termination.

8. *Ph. rotundifrons:* Tuberculo capitis antico ovato, lobis secundis triangularibus, tertiis minutis spiræformibus; oculis maximis; rhachi caudali 7-8 annulata, costis lateralibus sex. Long. 2″. Table IV, Fig. 2.

Ref.—EMMR. *Dissert.* 23. 10, *c*, Fig. *Pleur. laciniatus*, ROMER, *d. Rhein. Uebergangstel* 83. 69. 2, Tab. II, Fig. 8

Loc.—Described from an impression in plaster in the Museum at Berlin; the original was found at the Kalauerberg (in the Dietzhatze, in the Westerwald near Dillenburg).

Exactly similar to the preceding species in its entire habit; but the anterior large lobe of the glabella rather more oblong and of a short egg-shaped form; the second has the

form of a triangular lobe; the third of a narrow transverse protuberance, the margin of articulation exceeding it in point of width. The eyes are enormously large, and occupy the entire sides of the cephalic shield from the anterior to the posterior margin. There are eleven body rings.

Caudal shield oblong, trilateral, rather narrow, the axis furnished with seven distinct rings, the sides with six short ribs, and the extremity acutely angular.

Remark.—According to the researches of Römer (*d. Rhein. übergangsgel,* 83. 69. 2), this species possesses not merely elongated cephalic angles, but also dentations to the caudal shield, and belongs therefore to the last group, called by Milne Edwards *Pleuracanthus*. I have therefore indicated the cephalic angles and caudal points according to Römer's drawing in the former figure, which represented mere impressions in stone. Römer calls it *Pleur. laciniatus.*

9. *Ph. proœrus:* Tuberculo capitis antico rhombeo, secundo et tertio sensim minoribus, hoc a spire articulatoria, longius distante; rhachi caudali 8 annulata, costis lateralibus septem. Long. 2″. Table IV, Fig. 3.

Ref.—Emmr. *Dissert.* 25. 14.

Loc.—The Bohemian grauwacke of Ginec.

Comparatively shorter and broader than the preceding species; the anterior lobe of the glabella forming a highly convex, granulated, oblique, rhombic plate, to which the second wedge-shaped lobe is as closely joined as the third and narrower one, which is contracted laterally, is to this. The margin of articulation then follows posteriorly at a somewhat greater distance.

The eyes not large in proportion. They correspond entirely to the second lobe of the head, beyond which they do not project at all anteriorly, and but little posteriorly. I have not seen the body. The caudal shield is trilateral, heart-shaped, convex, pointed at the end, and has eight rings, successively becoming narrower, besides an ovate terminating joint; seven broad ribs, rather impressed longitudinally, are visible on the sides. The smaller anterior margin of articulation has been left out in this calculation; if we count it likewise, it would increase the number of rings, including the terminal joint, to ten.

Remark.—I have recently had opportunities of examining many specimens from the Mineralogical Museum of the University of Halle. In many of them there are distinct traces of long processes on the cephalic shield, and of a spine at the extremity of the caudal shield, which suggests the idea that *Phacops proœrus* may perhaps be identical with *Ph. mucronatus.*

Sub-group (c). The caudal shield is pointed at the extremity, and has no lateral spines

10. *Ph. Hausmanni:* Oculis maximis, usque ad limbum scuti cephalici extensis; rhachi caudæ 19-20 annulata, costis lateralibus 15. Long. 3-5″.

Ref.—*Isaph. Hausmanni,* Brongn. *Cr. foss.* 21. 3, Pl. II, Fig. 3, A, B. Schloth. *Nachtr.* ii, 20. 35, Tab. XXII, Fig. 7. Sternb. *Verhandl.* 1825, 77, Tab. II, Fig. 3, A-C. Dalm. *Paläad.* 66. 4. *Phac. Hausmanni,* Emmr. *Dissert.* 24. 13.

Loc.—The gray transition limestone of Bohemia, on the left shore of the Beraun, near Karlstein, and at the shores of the Moldau, near Kosorz and Branik.

The largest species of the genus, and particularly distinguished by its very large eyes, the lenses of which, however, are remarkably small. The glabella is shorter and broader

than in the other species of this group; the three central lobes are nearly of an equal size, and the eye reaches not only beyond the second, but even beyond the fourth, and almost as far as the broad flat margin. The posterior angle is moderately pointed, probably as long as four or five articulations. The large trilateral caudal shield has an axis of from nineteen to twenty-two joints, and from fourteen to fifteen lateral ribs. It is, however, moderately convex, and extended in a flat border at the circumference, which forms a carinated angle, pointed at the extremity. The surface is finely granulated wherever the shell is preserved, but smooth when it is absent; the lateral ribs, in the latter case,do not appear to be grooved, but merely flattened, but they have a double granulated ridge, of unequal height, when the shell is present.

Remarks.—1. Brongniart, who knew this species by fragments only, represented the caudal shield as being rounded at the posterior part, which probably may be in consequence of the defective state of his specimen. I therefore do not consider this caudal shield different from that represented by Sternberg and Schlotheim, as Milne Edwards supposes (see p. 312 of his work).

2. The angles of the cephalic shield are wanting in Count Sternberg's figure; they are, however, present in the perfect specimens which I saw at Berlin. A well-preserved head is very rare.

3. *Asaph. auriculatus*, Dahm. (*Palæad.* 6. 6. 3), which is based upon Count Sternberg's unknown individual (see his work, p. 80, Table II, Fig. 2), is beyond a doubt a smaller, younger specimen of *Ph. Hausmanni*, and therefore cannot be admitted as a species.

11. *Ph. caudatus:* Oculis minoribus, nec anticum nec posticum limbum scuti cephalici attingentibus; rhachi caudæ 14 annulata, costis lateralibus octo, limbo in apice acuminato. Long. 2-3″.

Ref.—*Trilob. caudat.* Brünn, *Kjob. Sellsk. Skrift.* N. S. i, 392. 3. Parkinson, *Org. Rem.* Pl. XVII, Fig. 7. Schloth. *Nachtr.* 35. 11 (or 21. 4).

Asaph. caud. Brongn. *Crust. foss.* 22. 4, Pl. II, Fig. 4, *a-c;* Pl. III, Fig. 9. Dalm. *Palæad.* 42. 2, and 65. 2, Tab. II, Fig. 4. Green, *Mon. of Tril.* 50. Buckl. *Bridg. Tr.* Pl. XLV, Figs. 9-11, and Pl. XLVI, Figs. 11, 12. Murchis. *Sil. Syst.* ii, 654, Pl. VII, Fig. 8, *a*.

Asaph. tuberculato-caudatus, Murchis. *Sil. Syst.* ii, 654, Pl. VII, Fig. 8, *b*. Milne Edw. *Crust.* iii, 308. 2 (specimens with the granulation well preserved).

Loc.—In a gray limestone in England (Dudley, Ludlow), in Sweden (Gothland), and in North America (Lockport).

This species is nearly allied to the following one, but has characteristic distinctions; the anterior tubercle of the head is very large, and laterally very much produced forwards, by which the eyes are thrown back; the latter are smaller than in *P. Hausmanni*. They do not reach beyond the anterior margin of the second lobe of the head, and only just reach the front at the posterior part; the posterior angles of the cephalic shield reach to the centre of the body rings, the latter are gradually more pointed towards the posterior part. The caudal shield has an axis with about fourteen joints, which is distinctly rounded at the posterior part, and does not pass into the spine at the extremity; there are eight ribs on the sides, each divided by a diagonal furrow; the broad expanded margin is lengthened into a moderately long point at the posterior part, which is usually nearly as long as one half the length of the axis.

12. *Ph. mucronatus*. Oculis mediis, lobo capitis secundo et tertio aequantibus, caudae rhachi 10-11 articulata, costis lateralibus 8-9, scuti apice mucronato. Long. 3-4″.

Ref.—*Asaph. mucronatus*, Brongn. *Cr. foss.* 24, Pl. III, Fig. 9. Dalm. *Palaead.* 42. 1. 65, Tab. II, Fig. 3, *a-b*. Schloth. *Nachtr.* ii, 37. 24. Milne Edw. *Crust.* iii, 308. 4.

Entomostr. caudatus, Wahlenb. *N. A. Upsal.* viii, 28. 4, Tab. II, Fig. 3; *Journ. d. Phys.* v, 91, p. 34, Fig. 4.

Phacops mucronatus, Emmr. *Dissert.* 24. 11.

Asaph. longicaudatus, Murch. *Sil. Syst.* 656, Pl. XIV, Figs. 11-14. Milne Edw. *Cr.* iii, 308. 3.

Loc.—The Silurian limestones of England (Dudley, Wenlock), of Sweden (Ostgothland at Borenshult, Schonen at Rostanga), in the clayslate of Mosseberg; likewise in the grauwacke rocks of the Eifel at Daun (Sack's collection) associated with *Homalonotus armatus*.

This species resembles the tenth in point of structure of the head, and the eleventh with regard to the caudal shield, and thus forms an intermediate link between them. According to Murchison's figure, its cephalic shield is pointed in the centre of the anterior margin, and has a glabella which is not so broad anteriorly with the first lobe, decidedly smaller than in the preceding species, but which in front penetrates with a slight point into the marginal point of the shield. The eye, rather smaller than in *Ph. caudatus*, but much smaller than in *Ph. Hausmanni*, neither projects beyond the second, nor at the posterior part beyond the third lobe of the head; the long spines of the posterior angles are more acutely prominent, and reach beyond the centre of the body. The lateral lobes of the body joints are pointed. The caudal axis is longer and more slender than in *Ph. caudatus*, and consists of from ten to fourteen rings, the last four being more or less distinctly separated; at the sides there are only eight ribs, of which the first six behind the foremost marginal rib exhibit a deep diagonal transverse furrow, which is particularly distinct in specimens without the shell; the margin is much narrower than in *Ph. caudatus*, and not broader towards the posterior part, owing to which the long spine of the extremity usually issues more suddenly from the margin of the shield; the spine extends itself in the shape of a convex protuberance as far as towards the end of the axis, and becomes as long as all its joints.

Remarks.—1. Though I only know this species from the descriptions of the authors enumerated, and the cephalic shield alluded to in Sack's collection, I am, however, convinced of its distinctness. Formerly I attributed to it fourteen lateral ribs on the caudal shield; but, owing to the diagonal transverse furrow, I am now aware that I counted the anterior five twice over; there are, in fact, only eight lateral ribs.

2. A number of species occur in Green's Monograph and its appendices, which do not seem to be different from *Ph. caudatus* or *Ph. mucronatus*; I content myself here by enumerating them; they are founded for the greater part upon caudal shields. *Asaph. cryptur*us, Green (*Transact. of the Geolog. Soc. of Pennsylvania*, i, 37, Plate VI), Harlan (*Med. et Phys. Res.* 303), Milne Edwards (iii, 313), a caudal shield with twelve rings of the axis, and ten ribs; judging from the form, appears to belong to *Homalonotus*. *Asaph. limulurus* (*Mon.* 18), Milne Edwards's species (iii, 307,) appears to be identical with *Ph. mucronatus*. *Asaph. pleuroptyx* (*Mon.* 55) belongs either to the latter mentioned species, or perhaps to *Ph. Hausmanni*. *Asaph. micrurus* (*Mon.* 56) is likewise a *Phacops* with a pointed caudal shield, the specific characters of which cannot be more accurately ascertained, and which probably belongs to one of the three species here described.

Rather more different from each other are some caudal shields with two end-points, which probably also belong to this genus; I saw plaster casts of them, or at least of the second species, at Berlin.

Asaph. selenurus, Green (*Mon.* 46), Eaton (*Geol. Text-Book*, 31), Harlan (*Med. and Phys. Research* 302), Milne Edw. (*Crust.* iii, 309).

Asaph. laticostatus, Green (*Mon.* 45). The caudal shield resembles that of *Ph. conophthalmus* (No. 6), and may possibly belong to *Ph. odontocephalus*, or to a similar species; it has twelve short joints in the rounded caudal axis, and nine lateral ribs, of which the two last run towards the obtuse end-points.

Asaph. myrmecoides, Green (*Sill. Journ.* vol. xxxii, p. 397), Harlan (*Med. and Phys. Res.* 303), still more resembles the caudal shield of *Ph. conophthalmus*, being equally short, broad, and diverging at the end, but it is much larger, being upwards of three inches in width. The obtuse, but comparatively not very broad axis, consists of from seventeen to eighteen rings, and on the sides we remark thirteen ribs; both are covered with large round tubercles.

Asaph. astragalotes, Green (*Sill. Journ.* vol. xxv, p. 325), Harlan (*l. c.*), I consider the caudal shield of a large individual of *Phacops latifrons*, or *Calym. bufo*, Green; it has from seven to eight rings at the axis, and five lateral ribs.

3. I am equally unable to interpret distinctly *Asaph. Powisii*, Murch. (*Sil. Syst.* ii, 661, Pl. XXIII, Fig. 9, *a*, *b*), which certainly is a decided *Phacops*, and belongs to the same group, together with *Ph. anchiops* or *Ph. sclerops*, but has remarkably small eyes. The body appears to me to fit but little to the cephalic shield, the rings are much too broad towards the margin of articulation of the cephalic shield. According to Emmerich (*Leonh. and Bronn, Jahrbuch.* 1845, p. 53), the head is identical with *Ph. sclerops* (No. 4); according to Portlock, on the other hand (*Rep. of Geol.* 297), the body belongs to *Asaphus*.*

Sub-group (*d*). The caudal shield having long spines on its whole circumference.

13. *Ph. arachnoides*: Scuto capitis in medio marginis antici acuto, angulis posticis valde productis; limbo scuti caudalis decies spinosa. Long. 1-1½″. Tab. IV, Fig. 7.

Ref.—*Asaph. arachnoides*, Goldf. *Leonh. and Bronn's n. Jahrb.* 1843, 561. 13, Tab. V, Fig. 3. *Paradox. gratei*, Rom. *Verst. d. Hertz.* 39, Tab. XI, Fig. 11. *Pleuracanthus punctatus*, Rom. *Rhein. Uberg.* 82. *Olenus punctatus*, Steinung, *Mém. de Soc. Géol. Fr.* i, 356. Honinghaus, *Epist. Cref.* 1835. Emmr. *Dissert.* 55. *Pleuracanthus aracha.* Milne Edw. *Crust.* iii, 329.

Loc.—In an ash-gray limestone of the Eifel, according to specimens in Höninghaus's and Sack's collections.

Cephalic shield oblong, parabolic, the centre of the anterior margin pointed, and rather curved upwards; the anterior lobe of the head very large, the three following successively smaller; eyes high, strongly arched, exactly equalling the length of the three posterior lobes of the head, each single eye furnished with 162 lenses; posterior angles of the cephalic shield very much lengthened, reaching as far as the ninth ring of the body. The latter gradually becomes rather broader as far as the fifth, afterwards again more narrow; the lateral lobes considerably broader than the rings, and lengthened at the end into a spine, which at each successive joint is larger than at the preceding. Caudal shield parabolic, rather flattened; the axis slender, thirteen-jointed, the sides furnished with five elevated ribs, which issue from the arched circumference, and at each side five spines, which become shorter from the anterior to the posterior part, and correspond with the ribs; the first

* The head and tail figured by Sir Roderick Murchison, under the name of *Asaphus Powisii*, are now known to belong to different Trilobites. The name *Asaphus Powisii* is retained for the tail, whilst the head is the cephalic shield of a *Phacops*, named by Mr. Salter, who has met with the tail of the species, *Phacops felinus*.—Ed.

spine is twice as long as the spine of the last joint of the body. The whole upper surface is granulated.

Remark.—The lateral angles of the cephalic shield are wanting in Höninghaus's otherwise very beautiful figure, and the body appears to be thirteen-jointed; but the perfect specimens, which were intrusted to me for examination by my colleague M. Germar, had the proportions I have stated. I likewise recognized in them their identity with three fragments in Sack's collection.

14. *Ph. stellifer:* Scuto capitis in medio marginis antici acuto, angulis posticis longissime productis; scuto caudæ undecies radiato. Long. 1¼″. Tab. IV, Fig. 8.

Loc.—An ash-gray limestone of the Eifel, according to specimens in Sack's collection.

The cephalic shield, of which I have a pretty perfect specimen before me, resembles perfectly that of the preceding species, but the anterior lobe of the glabella is comparatively larger, and the entire shield therefore a little longer; the proportions of both species seem to be the same in other respects. I am only acquainted with fragments of the joints of the body, and can therefore only state it as probable that they terminate in lateral spines. Of the caudal shield I have three specimens before me, which admit of being generally characterized. It is comparatively smaller than in the preceding species, the axis is only divided into five distinct joints at the anterior part, the joints afterwards are certainly still visible, but the articulation is indistinct (at the sides we may still distinguish six segments). Five ribs issue from the anterior joints to the circumference, which is upturned much as in the preceding species, but the spines issuing from it are all of equal length, comparatively much shorter and thicker, and they meet together at their bases, and between the two most posterior ones there is another but odd eleventh spine, which exactly fills up the gap.

Remarks.—1. The caudal shields represented by Wahlenberg (*Nov. act. Ups.* viii, 30, 5, Tab. II, Fig. 1) and by Brongniart (*Crust. fossil.* Pl. III, Fig. 7) perhaps also belong to this species; Dalman had before suggested that these did not belong to the head represented with them (*Palæod.* 66, 5).

2. *Peltura Bucklandi*, Milne Edw. (*Cr.* iii, 345, 1, Pl. XXXIV, Fig. 12), which perfectly corresponds with Brongniart's figure (*Cr. fossil.* Pl. IV, Fig. 9), perhaps likewise belongs to this species; I can certainly count eleven rings at the left side of both figures, and almost thirteen at the right side: the central terminal spine decidedly seems to be in favour of its affinity with *Phac. stellifer.*

C.

Trilobites capable of rolling themselves up, having the axis of the body diminishing posteriorly, and their facial sutures extending to the posterior margin of the cephalic shield.

The Trilobites of this group are rare, and belong to the middle and newer Palæozoic strata, more particularly to the Devonian rocks, but extending as far upwards as the carboniferous limestone. The number of the body rings varies from nine to twelve, and may vary in the species of one genus. The glabella is very convex, but divided only into indistinct lobes or furnished with slight lateral furrows. The axis of the body is very gibbous, and furnished with short articulations; the caudal shield likewise possesses a distinctly articulated axis, and radiated lateral furrows or lobes.

Genus 14.—Cyphaspis (Calymene, Roemer; Phacops, Goldfuss).

The cephalic shield is almost semicircular, but not quite so, the sides very much produced, the margin thickened all round (and therefore excavated in casts); the glabella very convex, resembling the half of an egg, without furrows, but furnished with two longitudinal protuberances close to the narrower posterior extremity. The surface of specimens in which the shell is absent is smooth, or very slightly granulated, but the shell when preserved is thickly and strongly granulated.

Eyes rather small, situated on high protuberances close to the glabella. The facial suture intersects the anterior margin on a line with the eyes, thence proceeds in an almost straight line towards the eye, from the posterior part of which it proceeds outwards, and penetrates the posterior margin very near the external angle; the latter is elongated into a spine.

Body rings eleven (or twelve?) smooth and, in well-preserved specimens, finely granulated; the first five are either furnished with a very pointed posterior angle, or are rounded off; the whole axis becomes gradually narrower towards the posterior part.

Caudal shield very small, with a short articulated axis, indistinct ribs, and a remarkably depressed circumference, which is not reached by the ribs.

Remarks.—1. The specimens upon which this genus is founded, are rare and well preserved. The high glabella is usually entirely wanting, but indications of it may easily be discovered where it was broken off.

2. Dr. Lovèn has described a Trilobite under the name of *Proetus elegantulus* (*Öfvers. K. V. A. Förh.* 1845, p. 51, Tab. 1, Fig. 1), which seems to belong to the genus *Cyphaspis*, or at least possesses many of its characters; it is said, however, to have twelve body rings.

C. ceratophthalma: Scuto capitis antice rotundato, glabella valde inflata, grosse granulosa; annulis trunci undecim, anticis spinosis, oculis altissimis, conoideis. Long. 1-1½". Tab. III, Figs. 3-4.

Ref.—*Phacops ceratophthalmus*, Goldf. *Leonh. und Bronn. n. Jahrbuch.* 1843. 365. Tab. V, Fig. 2. *Calymene hydrocephala*, Römer, *Verst. d. Harzgebirges*, 38. 4, Tab. IX, Fig. 7.

The cephalic shield is rather less than a semicircle, everywhere inclosed by a thick margin, and elongated into a spine at the posterior angles. Immediately before the spine a deep indentation is perceptible, the granulation then commences, and continually increases towards the middle, so that the highest tubercles are placed in the centre of the glabella. The latter, in point of form and convexity, may be compared to the larger half of an egg. It rises from the cephalic shield, and is furnished at the posterior part with two elliptical protuberances. The raised eye-tubercles correspond with the anterior extremities of these protuberances, upon which the conical eyes are placed. The body rings are very gibbous and finely granulated; each of the lateral lobes has a small indentation at its extreme angle, and the first five appear to me to be acutely pointed. The short caudal axis is three-jointed.

Remarks.—1. My figures were made up from five imperfect specimens, of which two are in the

University collection and three in Sack's museum. The body rings appear smooth, or at least the lateral lobes are so; the caudal shield, on the contrary, exhibits a distinct fine granulation.

2. I formerly included in this group *Calymene clarifrons*, Dalm. (*Palæad.* 75. 2, *Sars Isis*, 1835. 339, Tab. IX, Fig. 8), *Tril. sphæricus*, Boeck (*Gaea norv.* i, 14), *Phacops sphæricus*, Emmr. (*Dissect.* 20. 3), and erroneously connected with it *Asaph. dubius*, Münster (*Beitr.* v, 113, Tab. X, Fig. 12). The latter is, as Dr. Beyrich has shown, the hypostoma of a *Chirurus*; the former, however, is a fragment of a peculiar Trilobite, which Dr. Beyrich includes in his new genus *Sphærexochus*.

3. *Calymene bellatula*, Dalm. (*Palæad.* 36. 2, Tab. I, Fig. 1, Hising. *Leth. Suec.* ii, Tab. I, Fig. 5, Milne Edwards, *Crust.* iii, 321. 7, Emmr. *Dissert.* 31. 8), likewise does not belong to my genus *Cyphaspis*, as I formerly supposed, judging from a damaged specimen, but must be referred to a peculiar genus which Dr Löven (*ante*, p. 110) calls *Cybele*, and in which he also includes the *Calym. verrucosa*, Dalm. (*Arsber*, etc. 1827. 52), together with *Trilob. relatus*, Schloth. (*Petref.* supplement ii, 40, Tab. XXII, Fig. 5), found at Revel. I must refer to Dr. Löven's treatise for the characters of this new genus, which has been very thoroughly described by him.*

Genus 15.—PROETUS, Steininger, (ÆONIA, Burmeister; GERASTOS, Goldfuss.)

Cephalic shield semicircular, surrounded by a thickened margin; the posterior angles do not project perceptibly; the glabella is very convex, parabolic, rounded at the anterior part, undivided, without any lateral lobes; at the posterior part it is as broad as the margin, to which it is immediately joined. The facial suture projects over the anterior cephalic margin on a line with the eyes, is thence directed towards the eye, forms the covering plate, and runs at first straight, afterwards in an S-shaped curve, to the posterior margin, which it penetrates beyond the centre, in an oblique direction towards the external part.

Eyes of moderate size, very prominent, smooth, joined rather closely to the glabella.

Body axis ten-jointed, the joints gradually more narrow towards the posterior part, strongly arched, abruptly separated from the lateral lobes by a peculiar furrow, these lobes having an oblique indentation.

Caudal shield corresponding with the cephalic, but smaller, the axis highly arched, short, distinctly articulated, the sides furnished with slight furrows or obsolete ribs, the margin even, but having a very acute angle. The surface of the shell almost smooth, but with distinct traces of granulation on the glabella, and on the cheeks beneath the eye.

Remark.—Prof. Goldfuss described species of this genus under the name of *Gerastos*, but connected with them, as I also did, other Trilobites which do not belong to the group. Mistakes of this kind would have happened less frequently, if former authors had furnished us with as distinct illustrations as we have at present in my Monograph, and in the works of Goldfuss, Löven, Beyrich, and others.

P. Cuvieri: Protuberantia verticis latissima, longitudine vix angustiori, obsoletissime granulata; angulis scuti cephalici obtusis. Long. 1″. Tab. III, Figs. 1, 2.

* The following are the characters given by Professor Löven for his genus *Cybele*:—Caput breve latum. Scutum centrale sublunatum, latum. Sutura pone oculum subrecta, ad angulum ducta. Oculi minuti arcu infraorbitali elevato, angusto. Thorax articulis (in una specie) duodecim. Terga convexa. Pleuræ sulco longitudinali in partem anticam divisæ syndesmalem breviorem, et posticam, magis minusve productam. Pygidium thoraci ex parte conforme, minutum, ex articulis numerosis coalitis, quorum basales aliquot majores, pleuris præditi, reliquis in caudam lanceolatam arctius connatis. *Oversigt af Kongl. Vetenskap. Acad. Förh.* 1845. No 4, p. 110.—EDITORS.

Ref.– Steininger, *Bemerk. ü. d. Vorst. d. Eifel.* Trier, 1831. 4, No. 52. *Mém. de la Soc. Géol. de France*, i, 359, No. 52, Pl. XXI, Fig. 6 (1834). *Cerastos lævigatus*, Goldf. *Leonh. und Bronn. n. Jahrb.* 1843, 557, Table IV, Fig. 3.

Locality.—A yellowish-gray limestone of the Eifel, near Blankenheim, according to specimens in Sack's and the Academy collections.

Glabella not very convex, without distinct granulation; it does not reach the anterior margin, which is reflexed: eyes rather behind the centre, surrounded externally by an indented ring, the cheeks beneath them distinctly granulated, their angles rounded. Body rings not remarkable; the caudal shield rather small, and flat like the axis, the latter nearly eight-jointed, but the last joints indistinctly separated; the sides furnished with six, more or less deeply-marked, furrows.

Remarks.—1. The Trilobite above described I formerly considered to belong to *Calymene concinna*, Dalm. (*Palæad.* 40. 7, Tab. 1, Fig. 5; Milne Edw. *Crust.* iii, 325. 16; *Asaph. conc.* Emmr. *Dissert.* 35, 19). Dr. Löven, however, has since published a very accurate description of Dalman's species (49, Tab. 1, Fig. 2), and proved that it is not identical with *Proetus Curieri*. But he is of opinion that both Trilobites belong to the same genus, which I cannot admit. I prefer separating Dalman's species from the species of Steininger, giving the new genus my former designation of *Aeonia*, and distinguishing it from *Proetus* by the following characters:

Glabella (which is shaped like a violin) has at each side three slight furrows, is contracted behind in a pedunculated stape, and furnished with two little tubercles close to the peduncle. The angles of the cephalic shield terminate in long spines.

The eyes are oblong, lunate, and flatter than in the other. The axis of the body is comparatively narrower, but likewise ten-jointed.

The caudal shield is not so obtuse, its axis longer and narrower, and its sides have deeper radiations.

The following species belong to this new genus:

1. *Ae. concinna* (*Proetus concinnus*, Löven 1, 1; *Calymene conc.* Dalm.). The cephalic shield I have copied from Löven's figure. Tab. V, Fig. 8.

2. *Ae. Stokesii* (*Asaph. Stokesii*, Murch. *Sil. Syst* ii, 625, Pl. XIV, Fig. 6; Löven 50, Tab. 1, Fig. 3). From the figure by Löven I have copied the cephalic shield. Tab. V, Fig. 5.

3. *Ae. verticalis*, Mihi, Tab. V, Fig. 9 (*Cerastos cornutus*, Goldf. 558. 3, Tab. V, Fig. 1). This species is nearly related to the former, and perhaps identical. I have formerly described it from an imperfect specimen as *Trilobites verticalis*, and therefore did not recognize it properly: the present figure is more correct. The glabella is flat and fiddle-shaped, becomes gradually narrower towards the anterior part, and exhibits at each side three oblique sulcations, of which the posterior runs in a curve towards the posterior margin, nearly reaching it. Traces of granulation may be seen on its summit. The oblong, lunate eyes correspond to the two posterior cephalic lobes; they are externally surrounded at their base by a furrow. The margins of the cephalic shield form a protuberance, which passes over at the angle into the long powerful spine, but is sulcated at the upper part. The body joints are short, but rather broad, narrower, however, than the lateral lobes. The caudal shield is rather less than a semicircle, its axis acutely pointed, seven-jointed; the sides have five flat elevated ribs, their extremities gradually becoming broader and indented by an additional radiated furrow.

Occurs in the Eifel near Bensberg (Sack's collection).

2. *Calymene diops*, Green (*Mon.* 37, Fig. 2; *Monthly Amer. Journ. of Geol.* 559, Tab. XXII, Fig 2; Milne Edwards, *Crust.* iii, 323. 10; Harl. *Med.* and *Phys. Res.* 301). The figure, Tab III, Fig. 5, is copied from the specimen in plaster of Paris of the Berl. Museum; this species seems rather to belong to the new genus *Aeonia* than to *Proetus*, and I shall therefore not attempt a further description of it until I have accurately examined original specimens. The figure is sufficiently recognizable.

3. *Cerastos granulosus*, Goldf. (558. 2, Tab. V, Fig. 4), belongs decidedly to *Proetus*. It is distinguished from *Pr. Curieri* by its more elongated and more strongly granulated glabella, and by the more pointed angles of the cephalic shield.

Genus 16.—ARCHEGONUS. (PHILLIPSIA and GRIFFITHIDES, Portl.)

The cephalic shield is rather large, parabolic, moderately convex, with a margin but slightly thickened, the glabella is evident, but not so distinct as in the former genera, its form is different, its sections and lobes not very depressed. The posterior angles of the cephalic shield are either pointed or obtuse.

The facial suture commences at the anterior margin of the cephalic shield, turns thence somewhat inwards towards the eye, forms the covering plate, and extends in a curve to the posterior margin, which it intersects near the middle.

The eyes are small, particularly low, but frequently long, lunate, and of a finely transparent lattice-work.

The axis of the body consists of nine short, highly arched rings, and is only very slightly narrowed towards the posterior part; the lateral lobes are as broad as the axis, and have only a distinct oblique furrow.

The caudal shield is but very little smaller than the cephalic, its form parabolic; it is highly arched at the axis, and less so at the sides; the axis is distinctly articulated, and consists of twelve or more joints; the sides are furnished with radiated furrows.

The surface of the shell is granulated in most of the species, but in some it is finely lineated.

Locality.—The carboniferous limestone and other contemporaneous beds.

Remark.—When I first described this genus (which I did contemporaneously with Portlock), I knew accurately only one species, and owing to the shell of this species possessing a lineated surface, I placed *Archegonus* in the next group of Trilobites. This genus, however, has become better known since, and it has been proved that the shell of most species presents a granulated surface. I have therefore been obliged to alter its systematic position. The occurrence of two different kinds of markings in the same genus is a remarkable circumstance, but less enigmatical in this instance when we take into consideration that this genus represents the last type of the Trilobites, and therefore naturally would bring together characters which hitherto had been distributed over different contemporary genera. A similar combination takes place also in *Bronteus*.

The species may probably be grouped best in the following manner:

I. Those in which the glabella has three lateral furrows, which obliquely extend towards the posterior part, and become gradually larger; the posterior and largest separates a lobe which is more strongly arched and more projecting; and the elongated eyes correspond with the latter in position. The posterior angles of the cephalic shield are elongated in a granulated manner.—PHILLIPSIA, Portlock.

A. The glabella not broader towards the anterior part, but of the same breadth, and commencing from the eyes, afterwards parabolically rounded. The shell has a tubercular granulation, particularly at the axis.

To this belong the species, *Phill. Kellii*, Portl. (*Rep. of Geol. etc.*, 307, Table II, Fig. 1; *Phill. crenata*, Portl. (*l. c.* 307, Fig. 2; the figure in the same work marked Figs. 4. 10. 11. 12; the caudal shield in Brongniart's *Crust. foss.* Table IV, Fig. 12; *Phill. granulifera*, De Koninck, (*Mém. de l'Acad. Roy. de Bruxelles*, tom. xiv, Fig. 3; *Ej. Anim. foss. de la Belgiq.* 603. 4, Table LIII, Fig. 3.) Perhaps we may also include among this group *Asaph*

dubius, Münster (*Beitr.* 112, Table X, Figs. 1, 4, 5), together with *Cal. furcata* (ibid. Fig. 9.)

B. The glabella a little broader towards the anterior part, or at least broadly rounded, and more strongly arched at the extremity. The shell has a finer granulation, the eyes are very much elongated, and reach to the posterior margin of the cephalic shield.

To this group belong, *Phillipsia Jonesii*, Portl. (30. 8, Table II, Figs. 3 and 5); *Asaphus Dalmanni*, Emmr. (*Dissert.* 36. 21, *Goldf. in Leonh. and Bronn. u. Jahrb.* 1843, 561. 12); *Phillipsia derbyensis*, De Koninck (*Anim. fossile, etc.*, 601. 2, Table III, Fig. 2); *Calymene? aequalis*, v. Meyer (*Nova Acta Phys. Med. Soc. Caes. Leop. Carol. n. cur.* xv, 2. 100, Table LVI, Fig. 3).

II. The glabella with only one lateral furrow, which separates one indistinct lobe before the margin of articulation. The eye shorter, but higher, more remote from the glabella, and not projecting so far towards the posterior part.—Griffithides, Portlock.

a. The cephalic shield with horny, elongated angles, the surface of the shell at least partly granulated (e. g. on the cheeks).

To this belongs *Phillipsia globiceps*, De Koninck (599. 2, Table LIII. Fig. 1), and probably also *Griffithides longispinus*, Portl. 312. Table XXIV, Fig. 12).

b. The cephalic shield not elongated into processes, the surface of the shell without granulation, but with a lineated sculpture.

To this belong two species: 1. *A. globiceps*, Mihi (*Griff. globiceps*, Portl. 311. Plate II, Fig. 9; *Asaph. glob.* Phill. *Geol. of Yorksh.* 1, Table XXII, Figs. 16. 20; Emmr. *Dissert*, 35. 20). 2. *A. clariceps*, scuto capitis caudæque subparabolico, angulis illius rotundatis; axi caudæ duodecies annulata, sulcis scuti lateralibus octo. Long. 1", Table V, Fig. 3.

Archegonus æqualis.

Locality.—A grayish-brown grauwacke near Altwasser, in Silesia; received (from the same locality) from M. Boecksch through M. de Charpentier; in the Berlin Museum.

The cephalic shield is somewhat broader than long, the glabella very convex, moderately thickened towards the anterior part, marked by deep, transversely corrugated lines, contracted in the region of the eyes, and there provided with a slight sulcation, which separates an indistinct lobe before the margin of articulation. The posterior extremity of the eye corresponds with this furrow. The margin of articulation projects somewhat at the posterior part; the cephalic shield has, however, no reflexed, but only a slightly indicated marginal fold. The nine body rings are short, their lateral lobes rather broader than the axis, and very distinctly separated from it; the oblique transverse furrow is very visible. The caudal shield is parabolic, rather convex, especially the axis, and obtusely rounded. We distinguish in it from ten to twelve rings, separated according to their size, and about eight more depressed lateral furrows, between which there may also be perceived the more shallow diagonal furrows.

SECTION II.

Trilobites possessing the capacity of rolling themselves up, the body axis not shortened posteriorly, the shell finely lineated, the caudal shield not having radiated lateral furrows.—ASAPHIDÆ.

I have already made some necessary remarks respecting the structure of the shells of this group; an additional common characteristic, however, seems also to exist in the glabella, which is always simple and destitute of lobes, indistinct traces only of lateral lobes being occasionally recognized at its posterior contracted part. The caudal axis likewise has frequently no joints, but generally has them indistinctly marked, whilst the ribs on the sides of the shield are always entirely wanting, and are at the utmost only indicated by fine ridges or lines. With regard, however, to the width of the body rings I must remark that the central rings become rather broader than the anterior and posterior ones, and the axis has, therefore, only an equal width at the anterior and posterior part.

A.

The body axis consisting of ten equal rings.

Genus 17.—ILLÆNUS, (ILLÆNUS and BUMASTES.)

The cephalic shield may be best compared to the fourth part of a sphere, and is, therefore, bounded by curves on the posterior and anterior margins, and strongly arched between; at the posterior margin we recognize the glabella as a slight convexity on the surface; the anterior margin, on the other hand, is acutely angular, rather produced, and depressed.

The facial suture projects obliquely over the flattened margin, rises with a gentle curvature upwards to the eye, forms the covering plate over the latter, and thence turns again with a gentle curvature towards the posterior margin, which it intersects not far from the axis. Both sutures are connected on the flattened anterior margin by a transverse suture.

The eyes are semilunate, depressed, and smooth.

The body consists of nine or ten short but broad rings, which are not furnished with an oblique transverse furrow on the lateral lobes.

The large, almost semicircular, caudal shield is highly arched, and furnished with an indication of a short axis, as in *Broutes*.

The surface of the shell has fine, concentric, irregular lines or ridges, between which, as also on the parts which are not striated, there are impressed punctures.

Division A.—Axis of the body not broader than the lateral lobes, and distinctly separated from them.—ILLÆNUS, *auctorum*.

The species occur in the lower strata of the grauwacke formation.

1. *Ill. crassicauda*: Oculis margini postico scuti cephalici approximatis. Long. 1-3″. Tab. V, Fig. 2.

Entom. cr. WAHLENB. *N. A. Ups.* viii, 27. 2, Tab. II, Figs. 5, 6. DALM. *Palæad.* 51. 12, Tab. V. Fig. 2, *a, f.* BRONN, *Leth.* i, 115, C. 3, Tab. IX. Fig. 9, *a, b.* BOECK,

Gaea Norv. i, 34. Emmr. *Diss.* 34. 17. Pander, *Beitr.* 137, Tab. V. Figs. 9, 10. L. v. Buch, *Beitr.* 43. *Trilob. Esmarkii,* Schloth. *Isis,* 1826, 315, Tab. I, Fig. 8.

Cryptonymus Rudolphii, Eichw. *Observ. etc.* 50. § 56, Tab. II, Fig. 1, *a, b. Cr. Rosenbergii, ibid.* 48, Tab. III, Fig. 3, *a, b. Cr. Parkinsonii, ibid.* 51. § 57, Tab. IV, Fig. 1, *a, b. Cr. Wahlenbergii, ibid.* 50, Fig. 3, *a, b.*

Isoteles crassicauda, Milne Edw. *Cr.* iii, 300. 6.

The following seem to be young individuals of the same species.

Illænus peroralis, Murchis, *Sil. Syst.* iii, 661. Pl. XXIII, Fig. 7.

Locality.—Occurs in the transition limestone of Sweden; at Husbyfjöl, in East Gothland; at Osmundsberg, in Dalecarlia; in Esthonia, at Revel, and at St. Petersburgh; in England, in the Caradoc sandstones of Shropshire and Montgomeryshire.

This common Trilobite is easily to be recognized by its peculiar habit, and is distinguished from the following species by the eyes, which are situated far towards the posterior part, close to the borders of the head.

2. *Ill. giganteus:* Oculis in medio latere scuti cephalici. Long. 3-6″. Tab. III, Fig. 10.

Guettard, *Mém. de l'Acad. Roy. etc.* 1757, tom. xv, Tab. VII, Fig. 2; Tab. VIII, Fig. 1; Tab. IX, Fig. 1.

Occurs in the clayslate of Angers; according to a specimen in the academical collection at Halle. This species seems rare, and not to have been found by any observer since Guettard's time; it is, however, as distinct as any other species of Trilobite. The splendid specimen in the collection above named, of which I give an accurate figure, shows only the cast of the animal: but exhibits all the characteristics of *Illænus*, together with the peculiarity which marks it as a distinct species: this is seen in the position of the eyes, and is very manifest. The covering plate at each side of the cephalic shield is, however, only visible on the latter, the maxillary shield and the eye itself are wanting: I have endeavoured to indicate its position by a dotted line.

Division B.—The axis of the body comparatively broader, and only imperfectly separated from the lateral lobes by a slight longitudinal sulcation.—Bumastes, Murch.

3. *Ill. (Bu.) barriensis:* Oculis margini postico scuti cephalici approximatis. Long. 2-3″.

Murch. *Sil. System,* ii, 656, Pl. VII, Fig. 3, *a, b, c,* Pl. XIV, Fig. 7. Jukes and Sowerby, *Lond. Mag. of Nat. History,* ii, 41. Silliman, *Amer. Journ. of Science,* 1832, vol. xxiii, I. p. 203. Emmr. *Dissert.* 33. Milne Edw. *Cr.* iii, 295.

Locality—The middle Silurian strata of England, at Barr, in Staffordshire, at Brandlodge, and Presteign. This Trilobite resembles so much the *Ill. crassicauda,* with the exception of the body, the broad axis of which is not strictly separated from the lateral lobes, that I hesitated for some time before I could decide upon its being a different species. Isolated cephalic and caudal shields can scarcely be distinguished from the former.

Remark.—*Nileus glomerinus,* Dahm. (*Arsberatt,* 1828, p. 136; Hising. *Leth Suec.* 16), seems to be the same species.

B.

The body axis consisting of nine rings.

Genus 18.—DYSPLANUS.

Cephalic shield highly arched, large, semilunar, the posterior angles elongated into pointed processes, the glabella not more strongly arched, and no posterior prominent margin of articulation.

The facial suture describes in front a semicircle, bends towards the eyes, and extends with a gentle curve from the latter to the posterior margin; between its extremity and the glabella there is at each side a furrow.

Eyes small, slightly convex, scarcely rising above the level surface of the head, placed still further towards the exterior part than in *Illænus*, lunate, transparently reticulated.

Body axis rather convex, but the rings are short; the lateral lobes rather broader than the axis, strongly bent downwards, without diagonal furrows.

Caudal shield broad, semicircular, slightly arched, with a short, slightly indicated conical axis, without rings or lateral furrows.

The only known species is:

D. centrotus; *Asaph* (*Illænus*) *centrot.* DALM. *Palæad.* 51. 11, Tab. V, Fig. 1, *a. c.* BOECK, *Gaea Norw.* I, No. 35. EMMR. *Dissert.* 34, 18. *Isoteles centr.* MILNE EDW. *Crust*, 301. 7.

Locality.—The transition lime of Eastgothland, near Husbyfjöl, but of rare occurrence; found also at Christiania.

C.

The axis of the body consisting of eight equal rings.

Genus 19.—ASAPHUS, Brong. (ASAPHUS *et* NILEUS, Dalm.; ISOTELES, Dekay; HEMICRYPTURUS, Green.)

This genus embraces a widely extended group, if we define it according to the number of the rings of the body; but in addition to these it only exhibits one other generic character, derived from the course of the entire facial suture, on the upper side of the cephalic shield. Intersecting the margin at the posterior part, in the centre of the lateral lobes, this suture turns with the usual **S**-shaped curve towards the eye, forms over it the covering plate, and thence extends, describing an arch to the centre of the anterior margin. The two angles pass into one another, describing a semicircle, if the anterior margin is obtuse, and they form an angle with one another if the latter is pointed. The eyes themselves are large, high, and exceedingly prominent, although not quite so elevated as in *Phacops*; the thick horny membrane is smooth, but the lenses are not unfrequently seen through it.

The axis of the body is of equal breadth, rather broader perhaps towards the centre, and usually distinctly separated from the lateral lobes; the oblique transverse furrows are then visible likewise.

The caudal shield resembles the cephalic, either wholly or very nearly in point of

outline and shape, and has not always a projecting axis, but this axis, when visible, is usually articulated. Several subdivisions may be established in this large genus, and we may consider these as so many subgenera.

Group A. The lateral lobes not separated by any furrow from the axis of the body and with no transverse furrows; the trace of an axis wanting in the caudal shield, and the indication of the glabella in the cephalic shield. The facial suture describes a circle, the eyes are large, lunate, but not very prominent.—Nileus, Dalman.

1. *Asaphus* (*Nileus*) *armadillo*: Scuto capitis caudæque convexo brevi dilatato; angulis capitis posticis obtusis: thoracis axi lobis lateralibus latiori. Long. 1-2″.

Ref.—Dalm. *Palæad.* 49. 10, Table XIV, Fig. 3, *a-e*. Milne Edw. *Crust.* iii, 294. 1, Pl. XXXIV, Figs. 1, 2. Pand. *Beitr.* 132, Tab. V, Fig. 2. L. v. Buch, *Beitr.* 50. Hising. *Leth. Suec.* 16, Tab. III, Fig. 3. *Asaph. armad.* Emmr. *Dissert.* 33, 15.

Var. Minor: *Nileus chiton*. Pander, *Beitr.* 132, Tab. V, Fig. I. Milne Edw. *Crust.* iii, 295, 2.

Locality.—The transition limestones of Eastgothland, Husbyfjöl, and Skarpasen; in Dalecarlia, at Rathwick; in Esthonia, at St. Petersburgh.

Cephalic shield short, scarcely half as broad as long, uniformly convex, with rather acute margins; the eyes separated far from one another, reaching almost to the anterior and posterior cephalic margins, but depressed, and with a large covering plate.

The rings of the body short, without any division between axis and lateral lobes; the former, however, is indicated, and is almost twice as broad as the latter, which has no transverse furrows.

Caudal shield short, broad, curved at the basis, without a vestige of an axis.

Remarks.—1. It is easily distinguished from *Bumastes* (like which, however, it has an axis not separated from the lateral lobes) by the number of body rings, and not less so by the position and size of the eyes, and the comparatively inferior size and less convex shape of the glabella. It stands, however, in the same relation to the following group as *Bumastes* does to *Illœnus*, and, as in the latter case, there are analogous forms.

2. *Nil. glomerinus*, Dalm. (*Arsberatt* 1828. 136; Hisinger, *Leth. Suec.* 16). *Nil. glaberrimus* (Milne Edw. *Cr.* iii, 295), with small eyes and ten body rings, may probably be identical with *Bumastes barriensis*. Dalman's specimens were found at Husbyfjöl.

Group B. The lateral lobes of the rings of the body separated from the axis by a depressed longitudinal furrow. The diagonal furrows of these lobes seem to be always present.*

Subdivision A.—The facial suture describes an arch anteriorly, but is not angular.

a a. The glabella and caudal axis distinctly indicated, the latter not articulated and very short (?). The eyes are also flatter and depressed, lunate, and supported at the lower part by a portion of the cheek-shield, upon which they are borne; the diagonal furrows of the lateral lobes appear to be slight.—Symphysurus, Goldfuss.

* They have not been indicated in Dalman's figure in *Asaph. palpebrosus* and *A. læviceps*, but are mentioned in the description as being slight.

2. *As. palpebrosus:* Vertice tumido, marginem crassum scuti cephalici superante; oculis longissimis. Long. 1½-1¾″.

DALM. *Palæad.* 48. 9, Tab. IV, Fig. 2, *a-c.* EMMR. *Dissert.* 32. 14. MILNE EDW. *Crust.* iii, 299. 4. HISING. *Leth. Suec.* 15, Tab. III, Fig. 1, *a, b.*

Locality.—The transition limestone of Eastgothland, at Husbyfjöl. Having had no opportunity of examining a specimen of this or the following species, I must refer the reader to Dalman's detailed description.

3. *As. hericeps:* Scuto capitis caudæque in margine dilatato, acutangulo, axin superante; oculis brevioribus. Long. 2″.

DALM. *Palæad.* 47. 8, Tab. I, Fig. 1, *a-d.* EMMR. *Dissert.* 32. 13. MILNE EDW. *Crust.* iii, 305. 5. HISING. *Leth. Suec.* Tab. II, Fig. 8, *a, b.*

Locality.—The transition limestone of Eastgothland, at Husbyfjöl; but, like the preceding species, of rare occurrence.

b b.—The glabella and the caudal axis project distinctly as defined and convex portions, circumscribed by sulcations; the latter is also articulated. The eyes are elevated, but short protuberances, which reach only at the posterior part to the furrow at the maxillary shield. The angles of the cephalic shield are rounded. The axis of the body is narrower than the lateral lobes, and the latter have distinct diagonal furrows. *Hemicryptarus,* Green, *Cryptonymus,* Goldf. Eichw.*

4. *A. expansus:* Protuberantia verticis postice coarctata, utrinque juxta spiram articulatoriam nodosa; angulis scuti cephalici caudæque obtusis. Long 2-3″. Tab. V, Fig. 1, *a, c.*

Ref.—*Entomol. paradoxus* a, *expansus,* LINN. *S. Nat.* iii, 160. It. vel. 147. *c.* Fig. ROBERG, *Dissert. de Astac.* pp. 19, 20. KLEIN, *Spec. Petr. Gedan.* Tab. XV, Figs. 3, 4. SCHLOTH. *Leonhard's Taschenb.* 1810. 1. Tab. I, Figs. 1, 3. RAZOUMOWSKY, *Annal. de Scienc. Nat.* tom. viii, Pl. XXVIII, Figs. 2, 3, 5, 6, 7. *Entomostr. expans.* WAHLENBERG, *N. A. Ups.* viii. 25. 1. *Asaph. expans.* DALM. *Palæad.* 45. 6, Tab. III, Fig. 3, *a, d.* KLOD, *Verstein. der Mark Brandenb.* 108. BRONN, *Leth* i, 114. 1, Tab. IX, Fig. 7. EMMR. *Dissert.* 30. 10. HISING. *Leth. Suec.* Tab. II, Fig. 6. L. v. BUCH, *Beitr.* 41.

Asaph. cornigerus, Brongn. *Cr. foss.* 18, Pl. II, Fig. 1, *a, b*; Pl. IV, Fig. 10. PANDER. *Beitr.* 135, Tab. VI, Figs. 1, 4, 7; Tab. VII, Figs. 3, 4; Tab. VIII, Figs. 2-6.

Trilob. corniger. SCHLOTH. *Petref.* 38. 1, *Nachtr.* vi, 16, 34. *Trilob. Schwateri. ibid.* 35, 10, Tab. II, Fig. 3 (large caudal shield).

Cryptonymus Lichtensteinii, EICHW. 47, § 53, Tab. II, Fig. 3, *a, b. Cr. Panderi, ibid.* 47, § 52, Tab. III, Fig. 1, *a, b. Cr. Schlotheimii, ibid.* 45, Tab. IV, Fig. 2, *a, b. Isotelus expans.* MILNE EDW. *Crust.* iii. 304, 12. *Isot. Lichtensteinii, ibid.* 303, 11. *Hemicryptarus Rasoumowskii,* GREEN, *Mon. of Trilob.* 20.

Locality.—The transition limestone of Sweden, at Husbyfjöl, and Oeland; in Esthonia, at Revel and Petersburgh; in Norway, at Christiania; in boulders in Northern Germany. Wilken's figure in the Stralsund Mag. (I. Tab. II, Fig. 5, Tab. III, Fig. 11) seems to belong to this species.

Cephalic shield at the posterior part twice as broad as long, the entire external margin

suddenly deflexed, not produced. The glabella distinctly defined, broadest at the anterior, narrowing towards the posterior part, contracted in the shape of a peduncle before the margin of articulation, and there elevated in the centre into a protuberance; beside it, at each side, another more level protuberance, which extends to the eye. A deep furrow separates the margin of articulation from the cephalic axis, and the posterior half of the lateral surfaces from the other surface; it disappears, however, towards the obtuse, rounded, posterior angle. Eyes short, but prominent.

Axis of the body moderately arched, broader towards the centre than at either end, the separate rings strongly arched.

Caudal shield at the base broader than long, rather obtuse at the end, moderately convex, the axis even at the commencement rather narrower than the last ring of the body, obtuse at the posterior part, articulated anteriorly, but more or less distinctly so, (which depends on the size of the individual,) eight distinct rings in all, rarely more; the sides without ribs. The whole upper surface of the shell is not smooth, but covered with elevated fine ridges, which run obliquely towards the external and posterior part; between them are impressed points or dots, which are occasionally united into spiral lines; there are usually from seven to eight larger striæ on the sides of the caudal shield, which correspond to the joints of the axis. Badly-preserved specimens are so worn that they appear to be smooth.

Remark.—Perfect specimens are seldom more than three inches long, but caudal shields of much larger individuals have been found, especially in boulders (as in the collection at Halle). These (*Tril. Schræteri* seems to be the same species) must have attained the length of six inches.*

5. *Asaphus tyrannus:* Protuberantia capitis ovata; angulis scuti cephalici posticis caudæque acutis vel acuminatis. Long. 6-10″. Tab. V, Fig. 4.

Ref.—Murchis. *Sil. Syst.* ii, 662, Pl. 24. Emmr. *Dissert.* 29. 6. Milne Edw. *Cr.* iii, 310. 7.

Locality.—The Llandeilo flags of England, in Caermarthenshire, Pembrokeshire, and in boulders in a red limestone in the collection at Halle.

The cephalic shield is not yet sufficiently known; but Murchison's figure leaves no doubt that the facial suture described a circle at the anterior part, and that the posterior angles were much produced.

The large caudal shield, which I have represented, belongs undoubtedly to this species, and shows that Murchison's figure of its extremity represents it as rather too pointed. The sculpture of the upper surface, according to Murchison's figure, appears to be exactly the same as in the preceding species, only less delicate; it is wanting in my specimen; I have copied Murchison's figure in this respect.

Subdivision B.—The facial suture describes an angle at the anterior part, and is not semicircular.

a a.—The caudal axis projects, and is distinctly separated by a furrow in the shield.—Asaphus.

* The large caudal shields, of which I am here speaking, belong to *Isoteles Powisii*, Portl. (*Rep. of Irel.* 297, Pl. VI, Fig. 1), and must not therefore be identified with *Asaphus expansus*. I now very much doubt whether *Tril. Schræteri*, Schloth. belongs to it.

6. *Asaphus raniceps:* Scuto capitis parabolico, acuto, angulis posticis subacutis; rhachi caudæ subarticulata. Long. 3-4″.

Ref.—Dalm. *Palæad.* Table III, Fig. 4. *Crypton. Weissii*, Eichw. *Observ.* 46, § 51. Table II, Fig. 2, *a*, *b*. Milne Edw. *Crust.* iii, 304. 13. Razoumowsky, *An. des Sc. Nat.* viii, Pl. XXVIII, Fig. 1. Pander, *Beitr.* Table IV, C, Fig. 3 Table VI, Fig. XXIII. Table VII, Figs. 1, 5, 6. Table VIII, Fig. 7.

Occurs in company with *A. expansus*. This species has been taken for a variety of *A. expansus* by many authors, but is certainly a different species.

The whole cephalic shield, and especially the glabella, is much more depressed, the external margin produced and acutely angular, the anterior angle pointed. The eyes at the same time are always higher, the rings of the body comparatively flatter, the caudal shield parabolic, certainly not acutely angular at the posterior part, but much more lengthened; it is also more flatly arched, and the axis has only very slight indications of rings. Even if all these differences were to be considered as merely relative, and, therefore, as mere characters of variation, yet the remarkably acute, angular, facial suture, which is curved by the side of the angle, would constitute a good positive distinction.

The eyes are also situated rather more close to each other.

7. *Asaphus extenuatus:* Scuto capitis parabolico, acuto, angulis posticis in cornua productis; rhachi caudæ subarticulata. Long. 4-10″.

Ref.—*Entom. extenuatus*, Wahlenb. *N. Act. Ups.* viii, 295, Table VII, Fig. 4.

Asaph. exten. Dalm. 43. 3, Table II, Fig. 3. Hising. *Leth. Suec.* 13, Table II. Fig. 3. *Isotelus. exten.* Milne Edw. *Cr.* iii, 301. 8.

Individua maxima:—*Asaph. grandis*, Sars' *Isis*, 1835, 338, Table IX, Fig. 6, *a*, *b*. Milne Edw. *Crust* iii, 311. 9.

Found in a gray limestone of Eastgothland, at Husbyfjöl and Hela; in the black limestone at Aggersbakken, near Christiania.

The peculiar lengthened form of the cephalic shield, its greatly produced posterior angles, and the long, parabolic, but not actually pointed caudal shield, conspicuously distinguish this beautiful and rare species. The arch of the glabella is moderate, the furrowing between the eyes not very strong, and the thickened margin of articulation slightly developed. The rings of the axis are much more narrow than the lateral lobes, and very short, compared with the size of the caudal shield. The latter has a long parabolic form, and a slightly elevated axis, on which the rings are indicated in the horny shell as in *Asaph. tyrannus*, by little elevated transverse ridges, similar fine, radiating, minute ridges also appear at the sides. This I could perfectly distinguish in Sars' large individual, of which I found a plaster cast in the Berlin Museum. The latter appears to me to be different only in size; the specimens of Dalman and Wahlenberg appear to have lost their shell, or at least the sculptured surface, but this, according to all analogy, would be less considerable in small than in large individuals.

b b.—The caudal axis does not project, or projects but very little from the shield.

8. *As. (Isot.) platycephalus:* Scuto capitis caudæque parabolico, acuto; thoracis axi lobis lateralibus latiori, axi caudæ obsoleta. Long. 2-6″. Tab. II, Fig. 12.

Ref.—*Asaph. platyceph.* STOKES, *Trans. of the Geol. Soc. of London*, i, 8. 208, Pl. 27. *Isoteles gigas*, DEKAY, *Annals of the Lyc. of Nat. His. of New York*, i, 176, Pl. 12, 13. Fig. 1. DALM. *Palæad.* 70. 13. GREEN, *Mon. of Tril.* 67. BRONN, *Leth.* i, 115, Pl. IX, Fig. 8. EMMR. *Dissert.* 32. 12. MILNE EDW. *Crust.* iii, 298. 1. *Brongniartia isoleta*, EATON, *Geol. Text Book*, Pl. II, Fig. 19.

Found in a black limestone of Trenton Falls, in the state of New York; at Cincinnati, in the state of Ohio, and at other places. My figure, which is perfectly accurate, represents the impression of the lower surface of the shell, and, therefore, exhibits traces of lobes on the glabella and articulations in the tail, which are not recognizable in the upper surface. I convinced myself of the presence of a peculiar sculpture, consisting of dots, from remnants of it in the specimen from which my drawing is taken, which therein indicates a near affinity with *Asaphus expansus*. The acute shape of the posterior cephalic angles and of the lateral lobes of the body distinguishes *Isoteles* from the group of *Asaphus* marked *B a*, even if the shape were not distinct.

Remarks.—1. *Asaphus angustifrons*, Dalm. (*Palæad.* 14. 5, Tab. III, Fig. 2, *a*, *b*), of which I have seen a plaster cast at Berlin, seemed to me to be a member of this group, but the caudal axis projected rather more from the shield, and was not narrower than the body at the anterior part. This shortening, which seems to be indicated by furrows and little punctations at the lower side of the shell, is a peculiar feature of *Asaphus platycephalus*.

2. Green's *Isoteles planus* (*Mon*, p. 68), *stegops* (71), and *Isot. megalops* are individuals in different states of preservation, and of different sizes, but all belong to *Isot. gigas*. The same author's *Isot. cyclops* (p. 69), on the other hand, seems to belong to a peculiar species, nearly related to *Asaph. angustifrons*, if not identical with it. *Isotel. megalops* is based upon individuals which most nearly correspond with the one I have represented.

D.

Six-jointed Trilobites, capable of rolling themselves up, and having the axis of the body equally broad throughout.

Genus 20.—AMPYX, Dalman.

I am acquainted neither with original specimens, nor with casts of this genus, and cannot, therefore, give a sufficient explanation of it; judging from the figures and the descriptions of authors, it seems to be most nearly allied to those species of *Asaphus* which have a pointed cephalic shield. It has much produced angles, which are generally broken off, but it is distinguished from the species alluded to by its higher and more prominent glabella, and more projecting eyes. According to Dalman, the axis consists of six body rings (according to Sars, of five only), which are short, but have broad lateral lobes, on which (according to Sars) the transverse furrows can be seen. The caudal shield resembles the cephalic shield, and has a distinctly projecting, obtuse axis, in which six or eight rings are usually indicated; the ribs on the sides appear to be wanting.

Occurs in very old strata of the transition limestone; three different species are known, respecting which I beg to refer to the authors quoted.

1. *A. nasutus*, Dalm. *Palæad.* 54. 1; Emmr. *Diss.* 49. 1; Milne Edw. *Cr.* iii, 296. 1; Boeck, *Gaea Norw.* 1, No. 47.

In a gray limestone of Eastgothland, at Skarpasen and Husbyfjöl; occurs also in a red limestone of the Billinger Mountain at Sköfda.

2. *A. mammillatus*, Sars' *Isis*, 1835, 335. 3, Table VIII, Fig. 4, *a-c* (the caudal shield *d* probably belongs to a *Trinucleus*); Emmr. *Diss.* 49. 2; Milne Edw. *l. c.* 3; Boeck, *l. c.* No. 46.

Occurs in the transition limestone of Loadegaarts Oen, and Hjortnaestangen, near Christiania.

3. *A. rostratus*, Sars, ibid. 334. 2, Table VIII, Fig. 3, *a-c*; Emmr. *Diss.* 49. 3; Milne Edw. ibid. 2; Boeck, ibid. No. 5.

Found at the same places with the preceding species, but more rarely.

APPENDIX.

1.

The following species are enumerated in works which I could not obtain, for which reason they have not been referred to.

Ampyx incertus, Delongchamps, *Mém. de la Soc. Linnéenne de Calvados*, ii. 316, Pl. XX, Fig. 5. Milne Edw. *Crust.* iii, 297.

Asaphus Brongniartii, ibid. Pl. XIX, Figs. 1-5. Milne Edw. ibid. 313.

Asaphus quadrilimbatus, Philips, *Geol. of Yorkshire*, vol. ii, p. 239, Pl. XXII, Figs. 1, 2.

Asaphus obsoletus, Phil. ibid. Figs. 3-6.

Asaphus granuliferus, Phil. ibid. Fig. 7.

Asaphus seminiferus, Phil. ibid. Figs. 8-10.

Asaphus gemmuliferus, Phil. ibid. Fig. 11. Buckl. *Br. Tr.* Pl. XLVI, Fig. 10. According to Buckland's figure, this is probably the same species as that represented by Brongniart in the *Cr. foss.* Pl. IV, Fig. 12, and which I have mentioned when treating of *Archegonus æqualis*.

Asaphus truncatulus, Phil. ibid. Figs. 12, 13.

Asaphus megalophthalmus, Troast, *Mém. de la Soc. Geol. de France*, iii, 94, Pl. XI, Fig. 1.

Asaphus heros, Dalm. *Årsberätt om. nya. zool. Arbeten* 135, Stockholm, 1828. Hising. *Leth. Suec.* 13. Milne Edw. *Cr.* iii, 309. The author places this species beside *Phac. caudatus*.

Asaphus platynotus, Dalm. ibid. 135. Hising. *Leth. Suec.* 15. Milne Edw. *Crust.* iii, 304.

Calymene ornata, Dalm. ibid. p. 134. Hising. *Leth. Suec.* 11. Milne Edw. *Crust.* iii, 304. According to Milne Edwards, it is nearly related to *Calym. Blumenbachii*, but distinguished from it by the structure of the glabella. According to Dr. Beyrich (*Bohem. Tril.* 18), the species belongs to *Cheirurus*. See also Löven, *Öfvers K. V. A.* 1844, 68.

Calymene verrucosa, Dalm. ibid. 134, and *Palæad.* 76. Brongn. *Crust. foss.* Pl. IV, Fig. 11. Hising. *Leth. Suec.* 11. Dr. Löven enumerates this species in his new genus *Cybele*. (*Öfvers. K. V. A. Förh.* 1845. 109.)

Entomolithus derbiensis, Martin. *Petrificata derbiensia*, Pl. XLV, Fig. 1. Identical with *Asaphus globiceps*, Phil. (my *Archegonus globiceps*), according to a conjecture of Milne Edwards' *Crust.* iii, 313. Portlock (*Rep.* p. 312) seems to doubt the correctness of this reference.

Calymene phlyctænoides, Green, *Sill. Americ. Journ. of Science and Arts*, 1837, vol. xxxii, I. p. 167. Leonh. *and* Bronn, *Jahrb.* 1838, 363.

Trimerus platypleurus, Green, as above, p. 168.

Trimerus Jacksonii, Green, *l. c.* pp. 347, 364.

Cryphæus (perhaps the sub-group B *b* of *Phacops*) *Boothii*, GREEN, *l. c.* pp. 344, 363.
Cryphæus callitelus, GREEN, pp. 346, 365.
Asaphus Trimbii, GREEN, pp. 348, 365.

2.

I have now to add some remarks on species, which could not with any degree of certainty be included in my regular arrangement, partly because I had no opportunity of examining specimens, and partly also because the species themselves are not sufficiently known. Their characters, as far as hitherto ascertained, I now therefore place here at the conclusion of my work.

Asaphus frontalis, DALM. *Palæad.* 46. 7. EMMR. *Dissert.* 29. 7. MILNE EDW. *Cr.* iii, 311. Angulis scuti cephalici posticis rotundatis, protuberantia capitis bis bi-impressa, oculis distantibus; scuto caudæ rotundato, costis utrinque sex radiantibus. Found in the red limestone of East Gothland, at Ljung. The author compares this species with *Oggia Buchii*, and places it next to *As. expansus*. The impressions of the lower side of the shell are said to exhibit no striæ, as in *As. expansus*; but this probably refers only to the inner wall of the upper surface of the shell, and that is smooth everywhere. These striæ are found in all Trilobites on the free under surface of the dorsal shell. This species, according to Quenstedt, is identical with *Asaph. angustifrons*. (J. Wiegman's *Archiv*, 1837, i, 345.)

Asaphus Vulcani, MURCHIS. *Sil. Syst.* ii, 663, Pl. XXV, Fig. 5. MILNE EDW. *Cr.* iii, 314. I do not quite understand this species. I should not hesitate to associate it with *Calymene æqualis*, H. v. Meyer's, and to bring it under *Archegonus*, if it really has nine rings.

Asaphus corndensis, MURCHIS. *Sil. Syst.* ii, 663, Pl. XXV, Fig. 4. EMMR. *Dissert.* 27. 3. MILNE EDW. *Crust.* iii, 310, has already been mentioned (p. 70 of the original), but has not yet been properly placed. It certainly is not an *Oggygia*, as Emmerich considers: for it is clear, from the angularly-shaped diagonal furrows of the lateral lobes, and their rounded form, that the animal possesses the power of rolling itself up, which is not the case in *Oggygia*. I am rather inclined to take this species for a young individual of *Asaphus tyrannus*, accounting for the evidently shorter structure of the caudal shield by the youth of the individual, it being well known that many of the acute-angular parts of the living Crustacea are more obtuse during youth than at an advanced age. Doubts certainly might arise against the correctness of this conjecture, from the much longer terminating angle of the cephalic shield; but if we bear in mind that the spines of the young *Paradoxides bohemicus* (*Olenus gracilis*, Zenk.) are very long, this lengthened form of the cephalic angles might be the type of youth.

Asaphus tyrannus (ibid. Pl. XXV, Fig. 1) I have already mentioned (see ante, p. 108) as not belonging to the typical form, see Plate XXIV; and, indeed, it almost appears to me not to be an *Asaphus* at all, for I do not know any other species of that genus possessing such strongly projecting lateral lobes on the caudal shield, and such a broad axis of the body. We might be tempted to bring this form under *Asaphus extenuatus*, with the entire

contour of which it harmonizes best, if we might venture to assume that the two portions have been incorrectly represented in the drawing.

Calymene variolaris, Brongn. *Crust. foss.* 14. 3, Pl. I, Fig. 3, *a*, *c*, Parkins. *Organ. rem.* iii, Pl. XVII, Fig. 16. Dalm. *Palæad.* 61. 1. Buckl. *Bridg. Tr.* Pl. XLVI, Fig. 6. Münster, *Beitr.* iii, 34. 1, Table V, Fig. 1. Murchis. *Sil. System*, 655, Plate XIV, Fig. 1. Milne Edw. *Cr.* iii, 326. *Trilob. variolar.* Schloth. *Nachtr.* ii, 34. 3. *Phacops variol.* Emmr. *Dissert.* 20. 4. This species has already been mentioned (see ante, p. 83) as a form with which I am unacquainted. It has a semicircular cephalic shield with a very convex glabella which is undivided and broader at the anterior part, and with terminating angles which are suddenly produced into long points. The eyes are situated in the centre beside the glabella, on the surface of the cheek-shields, nearly as in *Calymene Blumenbachii*, presenting also the form of the latter. The body becomes more narrow towards the posterior part, and has distinctly thirteen rings in Murchison's figure, but only eleven in Brongniart's. The caudal axis, according to the reckoning of the latter, consists of twelve rings, and there are nine lateral ribs on the shield; in Murchison's figure I can only count seven lateral ribs, and from eight to nine joints in the axis. In addition to this, the whole upper surface of the body is covered with large, strong protuberances, which are almost entirely wanting on the body in Murchison's figure, but are represented in several rows upon the caudal axis, whilst Brongniart's figure also shows strong protuberances on the body, and only one central row on the caudal axis. Buckland's figure agrees with Brongniart's, and is probably copied from it. The species is found in the middle Silurian rocks of England, and also in the Fichtelgebirge, on the authority of Count v. Münster. The Count's figure agrees better with Murchison's than with Brongniart's; the long pointed angles of the cephalic shield are wanting in it, as in the one figured in the Silurian System.*

Judging from these statements, I am almost inclined to consider the different forms as being specifically different, and to call Murchison's species a true *Calymene*, Brongniart's and Parkinson's a *Phacops*. Boeck's assertion, however, that *Calymene variolaris* forms a distinct genus, to which the *Cal. punctata*, Auct. also belongs, is opposed to this assumption. (See Keilhaus, *Gaea Norv.* I. Trilob. No. 13.) The following authors treat of the last-named species.

Tril. punctatus, Brunn, *Kjöbenh. Sellsk. Skrivt. nye. Saml.* i, 394. 5. Schloth. *Nachtr.* ii, 37. 23. *Entomostr. punct.* Wahlenb. *N. A. Ups.* viii, 32. 7. Linnæus, *Act. Reg. ac. Holm.* 1759. 22. 24, Table I, Fig. 2. Lehmann, *Nov. Comm. Petropol.* x, Table XII, Fig. 10. Beckm. *Nov. Comm. Göthing.* iii, 102. Wilck, *Strals. Magaz.* iv, *St.* Table III, Fig. 12. *Calym. punct.* Brongn. *Cr. foss.* 36. Dalm. *Palæad.* 64. 12. Murchis. *l. c.* ii, 661, Pl. XXIII. Fig. 8. Milne Edw. *Cr.* iii, 327.

All of them merely describe caudal shields, with the exception of Wahlenberg, who also figures the central piece of the cephalic shield, which bears distinct marks of being a *Calymene*, especially in the thickened anterior margin of the head, and a peculiar structure of the lobes of the glabella, which reminds us of *Cal. Blumenbachii*. But I doubt whether

* *Cal. intermedia*, Münster (35. 2, Table V, Fig. 2), is said to have four sulcations on each side of the glabella, but resembles *C. variolaris* so perfectly in other respects, that I must yet doubt whether it forms a distinct species.

it really belongs to this species. The caudal shield, according to all the authors quoted, has a many-jointed axis, the rings of which bear a row of protuberances in the centre, and from seven to eight lateral ribs, of which each also has a protuberance on the centre. The ten rings of the body, represented by Dalman next to it, appear to be smooth. Such caudal shields are not uncommon in a pure whitish-gray limestone found in Gothland, a specimen of which, in my collection, contains two individuals, which, unfortunately, have the inner surface of their shell turned upwards, and the external surface so firmly fixed in the stone, that it is impossible to detach them. I can, however, distinctly recognize six central protuberances on the axis, which is the number that Dalman describes it to have, and on each side of them, the impressions of from twenty-eight to thirty rings, whilst the central region is surrounded by rings where the protuberances are situated. One ring corresponds to each protuberance, and I can count two rings between the first and the second protuberance, three between the second and third, two again between the third and fourth, three between the fourth and fifth, and four between the latter and the sixth, after which there are still six or seven behind the last tubercle: a greater number, however, may be existing at the upper side, where the rings are always more distinct. I can only find eight lateral ribs in my imperfect specimens, and no traces of protuberances,* which, indeed, can probably only be recognized on the external surface of the shell. The caudal shield of *Calymene variolaris*, according to Brongniart's and Buckland's figures, so perfectly corresponds with the structure above described (Parkinson's figure, I regret to say, I no longer have in my possession), that I do not believe I am wrong in stating the ordinary *Calymene punctata* to be identical with *Cal. variolaris* of the last-named authors. I propose, however, to retain the name of *Cal. variolaris* for Murchison's species so called, this being probably distinct; but I shall transfer the still older name of *C. punctata* to the *Calym. variolaris* of Brongniart, which, at an earlier period, was certainly known by that name. Not having been able to examine specimens myself, I must leave the question undetermined, whether this *Calymene punctata* really belongs to a distinct genus, or is a *Phacops; Calymene variolaris*, in my opinion, corresponds most nearly with the genus whose name it bears, and approximates very closely to those species of *Phacops* in which there is an undivided glabella, just as *C. Blumenbachii, C. Tristani*, &c., are analogous to those with a lobed glabella. The latter might still further be grouped according to the number and form of the lobes, as in the species of *Phacops*, were such subdivisions required by a large number of subgeneric forms.

Trilobites Sternbergii was so named by Boeck, in the *Mag. für Naturvidensk*, which I am not acquainted with. (See Sternberg, *Verhandl. d. vaterl. Mus. etc.*, 1833, 51.) Count Sternberg's figure in the work just cited (1825, Table I, Fig. 5) belongs to this species, and is briefly described at the conclusion of his treatise (p. 85.) My figures (Table III, Figs. 7, 8) agree perfectly with that given by him, and were sketched from Sternberg's plaster casts. Sternberg says of the cheeks, that they are prominent. I have only been able to recognize impressions in the cast. The eye was broken off in Sternberg's specimen, but its position and size are by no means left doubtful. The whole circumference visible has a reflexed, rounded margin. The black limestone of the Branikberg, in which

* This is the true structure, the prominent ends of the lateral ribs look like a row of tubercles.—Edit.

Phacops latifrons is found, contains also isolated cephalic shields of this rare species. Dalman, we know, has referred Sternberg's figure to his *Calymene speciosa* (*Palæad.* 76. 3), which, however, according to Beyrich, is a *Cheirurus*, as may be seen from Hisinger's figure (*Leth. Suec. suppl.* Table XXXIX, Fig. 2), but the two anterior furrows of the glabella do not traverse it entirely, and the third is bent down at each side of the centre, which is not the case in *Tril. Sternbergii*. It is also possible that Count Münster's *Calym. Sternbergii* (*Beitr.* iii, 37. 5, Table V, Fig. 5) and *Calym. propinqua* (ibid. 38. 6, Fig. 6), if the furrows of the head do not really unite across, correspond with *Phacops speciosus*, whilst *Calym. articulata* (ibid. 7, Fig. 7), with furrows of the head that do traverse, but which are badly drawn, is more immediately referrible to *Trilobites Sternbergii*. Dr. Beyrich enumerates all these species in his new genus *Cheirurus*.

I am not yet acquainted with anything further respecting the natural position of this species in the system. It I have already mentioned, and the next (see ante, p. 72).

Triarthrus Beckii, Green, *Mon. of Tril.* 86 et seq. *Monthly Americ. Journ.* p. 560. Harlan, *Med. and Physic. Res.* 305. *Bronguiartia carcinoidea*, Eaton, *Geol. Text-Book.* Bronn. *Leth.* i, 117, Table IX, Fig. 10. *Paradoxides triarthrus*, Harl. *Med. and Physic. Researches*, 401, i, Fig. 5. *Parad. armatus*, ibid. 402. 2, Figs. 1, 3. Milne Edw. *Crust.* iii, 345. Of these Trilobites we only know the central piece of the cephalic shield with the short parabolic glabella, on which the margin of articulation is indicated by a transverse furrow; laterally, however, there are two sulcations, produced in a diagonal direction towards the posterior part, which separate three nearly equal lobes. In this it entirely corresponds with the head of *Ol. scarabæoides* (see ante, p. 71). Nothing satisfactory can be said or conjectured with regard to the systematic position of this species, as the maxillary shields are wanting in all the specimens that have been examined, the rings of the body are merely known by fragments, and the caudal shield has not yet been found. Its affinity with *Olen. scarabæoides*, as shown by Harlan, is very readily seen; but the latter form also is as yet not sufficiently known to enable us to draw any inference from it in regard to the species at present under discussion. Harlan assumes, however, four body rings in *Parad. triarthrus*, and a short caudal shield, which is rounded at the circumference: he represents the lateral lobes of all the joints of the body as being more narrow than the axis; the latter is about equal to them near the head, but the lateral lobes rapidly become shorter towards the posterior part.

In the last respect, the new genus, *Remopleurides*, established by Portlock (*Rep.* 255, Pl. I, Figs. 1-6), in some measure approaches it. It appears also to have affinity with *Olenus scarabæoides*, and to belong to the group of *Olenidæ*.

Agnostus s. *Battus*. The discovery of several complete specimens of this singular genus of Trilobites has confirmed the view taken by Wahlenberg and Dalman (*Palæad.* p. 33), viz. that both the known forms of it belong to one and the same animal in the relations of cephalic and caudal shield. Dr. Beyrich has described a perfect specimen of a new species from Bohemia, and proved from the analogies of the latter with previously known shields, that the shields, which are usually rather larger, and furnished at the margin with two points, belong to the pygidium, and that the shields undefended at the margin and rather more convex, the axis being more narrow towards the front, belong to the head. According to this the genus might be characterized as follows:—

Genus AGNOSTUS, Brongn. (BATTUS, Dalman.)

Cephalic shield (Table V, Fig. 7) equally large as, or a little smaller than the caudal shield, similarly formed, very convex, margin elevated, or uniformly declining at the circumference, the axis more or less distinctly marked, narrower towards the front, provided the extremity be not very much enlarged, as it is in a new species *Agn. Rex*, Barr. This extremity is usually marked by a distinct transverse furrow; the basal part is not divided, or if so, at the utmost only by two small lateral lobes.

Facial suture and eyes not perceptible.

Body two-jointed, the axis of the joints depressed, broader than the furrowed lateral lobes.

Caudal shield (Tab. V, Fig. 6) usually rather broader, although not longer than the cephalic shield, the lateral margin rather less elevated, frequently ornamented with two marginal points; the axis considerably prominent, distinctly divided, usually furnished with an elevated longitudinal callosity, and two oblique lateral furrows, which extend towards the axis, and separate its rather broader extremity in the manner of a glabella. At the commencement of the axis there is a distinctly projecting marginal articulate fold.

Their power of rolling themselves up has not yet been ascertained.

Locality.—In the lower Silurian strata. The species have not yet been satisfactorily established, but there appear to be several.

1. *A. pisiformis*, Tab. V, Fig. 7, cephalic shield; Fig. 6, caudal shield. BRONGN. *Crust. foss.* 38, Pl. IV, Fig. 4, a, B. BRONN. *Lethæa geogn.* i, 123, Tab. IX, Fig. 20. MURCHIS. *Sil. Syst.* ii, 664, Pl. XXV, Fig. 3. MILNE EDW. *Crust.* iii, 348. 1. GR. v. MÜNSTER, *Contrib.* III, 47. 1. GOLDF. LEONH. *and* BRONN. *New Annual*, 1843, 542. 1. *Trilob. pisif.* SCHLOTH. *Petr. Suppl.* II, 36, 21. 26, 1. *Battus pisif.* DALM. *Palæad.* 57. IV. 1; 75. V. 1. HISING, *Leth. Suec.* 19, Tab. IV. Figs. 5, 6. LINN. *S. Nat.* iii, 160. 161. (ed. 12). BROMELL, *Act. lit. Ups.* 1729, 526. 4. *c* Fig. WILKENS, *Verst.* 75. Tab. VII, Figs. 38, 39. MODEER, *Schrift d. Naturf. Freunde z. Berlin*, 14, 248. Tab. II, Figs. 1, 2.

Locality.—In the alumslate and stinkstone of Andrarum, at the Kinnekulle, etc., and in similar strata in England.

2. *A. levigatus.* DALM. *Årsberäth.* 1828. 136. HISING. *Leth. Suec.* 20. 2. GOLDF. *l. c.* 542. 2. At the Kinnekulle, near Hönsater.

3. *A. integer*. *Battus integer*, BEYR. on Bohemian Trilobites, 44, 1, Fig. 19. In the lower Silurian strata of Bohemia.

4. *A. nudus*. *Battus nudus*, BEYR. as above, 46. Fig. 20.

Remark.—My figures of *A. pisiformis* (Table V, Figs. 6, 7), owing to the fault of the artist, were not formerly quite true to nature, and they have therefore been somewhat altered, so that they now certainly appear different, but decidedly more correct, although even now the shades of the furrows may perhaps be rather too deep. The smaller forms (formerly Figs. 5 and 8) do not deviate so materially as to render a particular representation of them necessary, and they have therefore been set aside to make room for other figures of more consequence.

3.

The descriptions and representations of the following species appear to me to be wholly unavailable for systematic arrangement; I merely enumerate them for the sake of completeness, and will not venture upon any conjectural construction.

Asaphus Cawdori, MURCHIS. *Sil. Syst.* ii, 655, Pl. VII, Fig. 9. MÜNSTER, *Beitr.* iii, 38. 1, Tab. V, Fig. 8.

Asaphus subcaudatus, MURCHIS. ibid. Fig. 10; probably only a larger individual of the preceding species.

Asaphus diurus, GREEN, *Sill. Americ. Journ.* 1839, vol. xxxvii, p. 40. A species related to *As. selenurus*, therefore a *Phacops*, with a double-pointed end of the caudal shield. (See ante, p. 95.)

Asaphus pusillus, MÜNSTER, *Beitr.* iii, 39. 2, Tab. V, Fig. 9.

Asaphus brevis, ibid. 39. 3, Fig. 10.

Asaphus grandis, ibid. 39. 4, Tab. IX, Fig. 1; a fragment of a caudal shield, which is probably different from Sars' species of the same name. (See p. 109.)

Paradoxides brevimucronatus, ibid. 40. 1, Tab. V, Fig. 12, seems to be a *Lichas laciniatus;* but, according to Dr. Beyrich (*Böhm. tr.* 16), it is a *Cheirurus.*

Bumastes franconicus, ibid. 42, Tab. V, Fig. 7. Cephalic and caudal shield without any specific characters.

Bumastes planus, ibid. 43. 2, Fig. 18, a larger, more compressed individual of the preceding species. *Trinucleus* (?) *Nillsoni*, ibid. 46. 5, Tab. V, Fig. 25; *Trinucl.* (?) *Otarion*, Tab. VI, Fig. 26, and *Trinucleus intermedius*, ibid. V. 116, Tab. X, Fig. 10, are fragments that cannot be distinctly recognized, but they are hardly *Trinuclei.* According to Dr. Beyrich, they are parts of the cephalic shield of *Bronteus* (*Calymene*) *furcata*, MÜNSTER, *Beitr.* V, 113. 2, Tab. X. Fig. 9; it has a semicircular, granulated, caudal shield, with a many-jointed axis, and seven lateral ribs that are slit to one half of their length.

After I had brought my work to a conclusion, and was engaged in preparing the index, I received the second series of the 'Magazin für Naturvidenskaberne,' (second series from 1832, vols. i and ii.) This series contains some remarks by Esmark on the following five Trilobites; see vol. i, p. 268, Tab. VIII.

1. *Tril. Asellus*, a ten-jointed Trilobite, incapable of rolling itself up (Fig. V), with a large caudal shield, the axis of which is wanting, but which nevertheless seems to be many-jointed. Boeck represents this species in Keilhau's *Gaea Norvegica* (1 Tril. No. 36), placing it next to *Illaenus centrotus*, Dalm., but between this and Esmark's figure there is no resemblance.

2. *Tril. elliptifrons*, p. 269, Figs. 6, 7, a *Phacops*, with an undivided, narrow glabella, which seems most nearly to resemble that of *Ph. latifrons*, but which, perhaps, differs from it specifically in the narrow shape of the glabella, if the figure be correct. Boeck, who treats of this species (*l. c.* No. 1), likewise distinguishes it from *Ph. latifrons*, his *Tril. elegans*; Sars (ibid. No. 2, "by the wide (long?) elliptical glabella." Both are found at Malmöckalven.

3. *Tril. sphæricus*, Fig. 8, according to Boeck, (*l. c.* sub No. 14,) is identical with *Tril. clavifrons*, Sars, concerning which I have already expressed my opinion (see ante, p. 99), connecting it with Dalman's species of the same name. But Esmark's figure exhibits three furrows on the glabella, and I am therefore still in doubt whether *Tr. sphæricus* can really be Sars' *Tr. clavifrons*. If, however, this be the case, it would belong to *Cyphaspis clavifrons*.

4. *Tr. semilunaris*, Fig. 9, according to Boeck's conjecture, (*l. c.* sub No. 10,) is only a small individual of *Phacops caudatus*. (See ante, p. 94.)

5. *Tr. dentatus*, Fig. 10, is a large caudal shield, with a many-jointed axis, and three large lateral ribs curved backwards (the figure indicates 15 rings, and an oval terminal joint); the ribs project over the margin of the shield in the shape of obtuse spines. Boeck adds (*l. c.* sub No. 7), that the semicylindrical glabella, which is rounded at the anterior part, has three lateral furrows, and that the posterior angles of the shield terminate in spines like the lateral lobes of the body rings. This species, therefore, is decidedly a *Phacops* of the division B *d*, and approximates to *Phac. arachnoides*. From these statements there appears now to be scarcely a doubt that it belongs to Dr. Löven's new genus *Cybele*.

I likewise only received the work of F. A. Römer, mentioned at the conclusion of the bibliography, very recently. The author describes in it the following Trilobites:

1. *Brontes flabellifer*, p. 37, Tab. II, Fig. 1.

2. *Br. signatus*, ibid. p. 37, Figs. 2, 3; citing also Phillips, *Palæozoic fossils*, Tab. LVII, Fig. 255; a caudal shield of a shorter, more circular, form.

Br. (?) *glabratus*, ibid. Fig. 6. The central piece of a cephalic shield possessing the shell, but otherwise without satisfactory characters.

4. *Calymene Jordani*, ibid. Fig. 4, certainly only a specimen of *Phacops latifrons*. I have a well-preserved specimen of this species lying before me (from the collection at Halle), which was found in the ground of the monastery at Michelstein, near Blankenburg. Römer also refers to this specimen (p. xviii of his work).

5. *Cal. Schusteri*, p. 38, Tab. XII, Fig. 42. The caudal shield of a small individual of *Phacops latifrons*.

6. *Cal. subornata*, ibid. Figs. 40, 41. It can hardly be that both these fragments belong to the same species. The species cannot be recognized from these figures.

7. *Cal. hydrocephala*, ibid. Tab. XI, Fig. 7. Beyond a doubt the central piece of a cephalic shield of *Cyphaspis ceratophthalma*. (See p. 98.)

8. *Asaphus Zinkenii*, ibid. Fig. 8. The central piece, without a shell, of the cephalic shield of *Ph. latifrons*.

9. *Paradoxides Grotei*, ibid. p. 39, Tab. XI, Fig. 11, *a*, *b*. Distinct fragments of *Phacops arachnoides*.

10. *Homalonotus Ahrendii*, ibid. Fig. 5, *a*, *b*. Certainly not different from *Hom. Knightii*, Murch.; for the distinctions enumerated originate from the changeable curvature of the rings towards each other, and merely relate to individual peculiarities.

11. *Hom. punctatus*, ibid. Fig. 9, and *Hom. gigas*, Fig. 10, are probably only fragments of other individuals of the same species; the punctation distinctly indicates the granulation originally present.

A notice of rather older date, which I have just received, occurs in *Sillim. Americ. Journ. of Sciences and Arts*, vol. xlii, p. 366. 1842. Mr. J. Locke describes there a new species of Trilobite as—

Isoteles megistos (there is a figure in Plate III of the same work). This drawing, nearly a foot in length, is nevertheless very imperfect, since no oblique transverse furrows are indicated on the lateral lobes of the rings of the body, and all positive characters are wanting on the posterior half of the cephalic shield. In addition to this, the figure has exactly the proportions of *Asaph. platycephalus* (*Isot. gigas*), but has short, terminating spines at the lateral angles of the cephalic shield. From this it certainly seems to be a distinct species, distinguished from *As. platycephalus* by the last-mentioned character, from *As. angustifrons* by its broad forehead, if transverse furrows exist on the lateral lobes; it would, however, belong to *Nileus* if the latter are wanting, which I doubt. The anterior extremity of the facial suture describes an angle, and indicates a similarity with the division B *b* of *Asaphus*.

M. de Castelnau has communicated to the French Institute (1842, p. 74) some observations respecting the feet of Trilobites, which he states he has observed in rolled-up individuals in North America. As his statements coincide entirely with the results which I have arrived at from analogy, his observations seem to deserve every credit; but nevertheless I can scarcely help doubting their correctness.

SUPPLEMENTARY APPENDIX.

BY THE EDITORS.

In order to render this work more readily complete and consultable for the student of British fossils, the Editors have added the following catalogue of published British Trilobites. It consists of the list of Trilobites, in alphabetical order, given by Mr. Morris in his valuable Catalogue of British Fossils, with a concordance showing their names or the places where they are referred to in this edition of Professor Burmeister's Monograph; also a list of such new Trilobites as have been described by Mr. M'Coy since the publication of Mr. Morris's Catalogue. Through the kindness of Mr. Salter they are enabled to add the names of the new species described by him in Professor Sedgwick's forthcoming work on the 'Geology of Wales and Westmoreland.'

They have also appended some useful extracts from recently published foreign works on Trilobites.

I. Alphabetical List of British Trilobites, with their Synonymes in this work, or references to the pages wherein they are mentioned.

Acidaspis, Murchison
Brightii, Murchison. Odontopleura elliptica? p. 63.

Amphion, Pand.
frontilobus, Pand. Calymene polytoma, p. 81.
gelasinosus, Portl. Cheirurus sp. p. 71, note.
multi-segmentatus, Portl.
pseudo-articulatus, Portl.

Ampyx, Dalman
Austinii, Portl.
baccatus, Portl
rostratus, Sars. See p. 111.
Sarsii, Portl.

Agnostus, Brong.
pisiformis, Brong. See p. 117.
tuberculatus Murch. See Odontopleura ovata. p. 62.

Arges, Goldf.
plano-spinosus, Portl. Cheirurus sp. p. 71, note.

Asaphus, Brong.
astragalotes, Green. See p. 96.
Buchii, Brong. Ogygia Buchii, p. 59.
caudatus, Brong. Phacops caudatus, p. 94.
Cawdori, Murch. See p. 118.
Corndensis, Murch. See remarks, p. 61, and p. 113.
cornigerus, Brong. Asaphus expansus, p. 107.
dilatatus, Dalm. Under Ogygia Buchii, p. 59 (but distinct.—Ed.)
duplicatus, Murch. See remarks, p. 61.
? gemmuliferus, Phil. Archegonus æqualis, p. 101.
? granuliferus, Phil. Appendix, p. 112.
latifrons, Portl.
longicaudatus, Murch. Phacops mucronatus, p. 94.
marginatus Portl.
Myops, Konig.
quadrilimbatus, Phil. Appendix, p. 112.

Asaphus.
Stokesii, Murch. Proetus Stokesii, p. 100.

ASAPHUS.
subcaudatus, Murch. Appendix, p. 118.
tuberculato-caudatus, Murch. Phacops caudatus, p. 94.
Tyrannus, Murch. Ibid. p. 108, and p 113.
Vulcani, Murch. Appendix, p. 113.

BRONTES, Goldf.
flabellifer, Goldf. p. 65.
signatus, Ph. See Appendix, p. 119.

BUMASTES, Murch.
Barriensis, Murch. Ilænus barriensis, p. 104.

CALYMENE, Brong.
Blumenbachii, Brong. Ibid. p. 81.
brevicapitatus, Portl.
Downingiæ, Murch. Phacops macrophthalmus, p. 92.
granulata, Munst. Phacops latifrons, p. 87.
lævis, Munst. Phacops lævis, p. 89.
Latreillii, Stein.
multisegmentatus, Portl.
pulchella, Dalm. Calymene Blumenbachii, var. p. 82.
Sternbergii, Munst. Cheirurus sp. p. 71, note.
tuberculata, Murch. Phacops latifrons, p. 89.
variolaris, Brong. See p. 83, note, and p. 114.

CERATURUS, Green
globiceps, Portl.

EURYPTERUS, Harlan.
Scouleri, Hibbert. See p. 54.

GRIFFITHIDES, Portl.
globiceps, Portl.
longiceps, Portl
longispinus, Portl.
platyceps, Portl.
} See Archegonus, p. 101, and Appendix, p. 112.

HARPES, Goldf.
Doranni, Portl. See p. 75, note.
Flanaganni, Portl. See p. 75, note.
macrocephalus, Goldf. See p. 75.

HOMALONOTUS. Konig.
delphinocephalus, Murch. Ibid. p. 56.
Herschelii, Murch. Ibid. p. 87.
Knightii, Konig. Ibid. p. 86.
Ludensis, Murch. Under H. Knightii, p. 56.

ILLÆNUS, Dalm.
centrotus, Dalm. Dysplanus centrotus, p. 105.
crassicauda, Dalm. Ibid. p. 103.
? perovalis, Murch. I. crassicauda junr. ? p. 104.
quadrato-caudatus, Portl.

ISOTELES, Dekay.
arcuatus, Portl
gigas, Dekay. Asaphus platycephalus, p. 110.
intermedius, Portl.
laviceps, Portl.
ovatus, Portl.
palpebrosus, Dalm. p. 107.
planus, Dekay.
Powisii, Portl. See note p. 96 (includes Phacops felinus, Salter).
rectifrons, Portl.
sclerops, Green.

NUTTAINIA, Eaton.
Hibernica, Portl. Lichas sp. p. 66, note.
? obscura, Portl.

OGYGIA, Brong.
Murchisoniæ, Murch. Ogygia Guettardi, p. 60.
rugosa, Portl.

PARADOXIDES, Brong.
? Bucephali. Portl.
bimucronatus, Murch. Chirurus sp. p. 71, note.
quadrimucronatus, Murch. Odontopleura elliptica, p. 63.

OLENUS, Dalm.
punctatus. Stein.

PHACOPS, Emmerich.
Brongniartii, Portl. Phacops latifrons, p. 88.
Dalmanni, Portl.
Jamesii, Portl.
Murchisonii, Portl.
truncato-caudatus, Portl.

PHILLIPSIA, Portl.
Jonesii, Portl.
Kellii, Portl.
Maccoyii, Portl.
obsoleta, Phil.
ornata, Portl.
raniceps, Phil.
seminifera, Phil.
} See Archegonus, p. 101, and Appendix, p. 112.

REMOPLEURIDES, Portl. p. 116.
Colbii, Portl.
dorso-spinifer, Portl.
lateri-spinifer, Portl.
longi-capitatus, Portl.
longi-costatus, Portl.

TRINUCLEUS, Lhwyd.
? Asaphoides, Murch. See remarks, p. 58.
Caractaci, Murch. Ibid. p. 56

TRINUCLEUS
elongatus, Portl.
fimbriatus, Murch. Ibid. p. 57.
latus Portl.
Lloydii, Murch. T. granulatus, p. 57.
nudus, Murch. an *Ampyx*. (note, p. 57).
? punctatus, Murch.
radiatus, Murch. Trinucleus ornatus, p. 58.
seticornis, Portl. p. 58.

II. To the above List of British Trilobites must be added those species described since the publication of Mr. Morris's Catalogue, and which have not come under the inspection of Professor Burmeister.

In Mr. M'Coy's 'Synopsis of the Carboniferous Fossils of Ireland,' the following new species are described and figured:*

Griffithides calcaratus.	Phillipsia (?) discors.
Phillipsia celata.	Phillipsia mucronata.
Phillipsia Colei.	Phillipsia quadriserialis.

In Mr. M'Coy's 'Synopsis of the Silurian Fossils of Ireland,' collected by Mr. Griffith (Dublin, 1846), the following new genera and species are described and figured:

TIRESIAS. New genus. "Cephalo-thorax semioval, longitudinal; glabella very gibbous, pyriform, rounded in front, contracted into a narrow neck posteriorly (obscure traces of two small cephalo-thoracic furrows on each side); neck furrow very strong; cheeks triangular, gibbous, prolonged backwards into long flattened spines; eyes none?"

"This remarkable Trilobite agrees nearly in form with the carboniferous genus *Griffithides*, Portl., except in being apparently blind." (Loc. cit. p. 43.) One species, *T. insculptus*, in the limestone of the Chair of Kildare.

FORBESIA. New genus. [From the description and figures this genus would appear to be synonymous with Proetus.] *F. latifrons*.

PORTLOCKIA. New genus. Cephalo-thorax truncato-orbicular, lateral angles not produced into spines; glabella large, clavate, widest in front, reaching to the margin, contracting to a narrow neck behind; neck furrow strong; cheeks rather small, triangular, convex; eyes large, reniform; abdomen of thirteen segments, rounded at their extremities, anterior margin sharpened for contraction; pygidium semi-elliptical, of seven simple segments; margin entire, smooth.

The genus includes *Calymene tuberculata* and *C. macrophthalma* of the Silurian system; *Phacops tuberculata* of Captain Portlock's report; *Calymene aspera*, Hall; *Calymene bufo*, Green, &c.

* In the same work are described and figured the following allied Crustacea from the carboniferous limestone of Ireland: Dithyrocaris (Scoular) Scouleri; Entomoconchus (new genus, M'Coy) Scouleri; Cytherina Phillipsiana of De Koninck; Daphnia primæva; Bairdia (new genus, M'Coy) curtus. B. gracilis; Cythere amygdalina, C. arcuata, C. bitubereulata, C. costata, C. cornuta, C. elongata, C. excavata, C. gibberula, C. Hibbertii, C. impressa, C. inflata, C. inornata, C. oblonga, C. orbicularis, C. pusilla, C. scutulum, C. spinigera, C. tritubereulata.

Trinodus. New genus. Cephalic shield truncato-elliptical; glabella convex, nearly cylindrical, sharply defined; cephalo-thoracic furrows, one on each side confluent with the next furrow, and with that defining the glabella, retroflexed to form a small flattened tubercle on each side of the base of the glabella; neck segment small, narrow, convex, surrounding the glabella in front, the portion in front of the glabella as wide as that at the sides; cheeks surrounded by a thick, flattened, entire margin, of equal width all round; eyes none, facial suture (? none); caudal shield equal, and similar in form to that of the head; axal lobe semicylindrical, very convex, divided by three segmental furrows, and having usually a prominent, lengthened tubercle extending down the middle, and which is not cut by the segmental furrows; lateral lobes almost equal to the axal, very convex, not marked by the segmental furrows; portion encircling the obtuse apex of the axal lobe about equal to that of the sides, surrounded by a flattened margin, less than the side lobes in width." *T. agnostiformis.*

Remopleurides laticeps.
Acidaspis bispinosus.
Sphærexochus calvus. [Calymene clavifrons of Dalman.]
Encrinurus Stokesii. [Calymene variolaris of authors.]
Calymene arenosa.
Calymene ? forcipata (a Lichas?).
Portlockia sublævis.
Lichas laxata.
Lichas pumila
Homalonotus ophiocephalus.
Otarion obtusum.
Harpes ? megalops.

Mr. M'Coy, in the same work, has placed the *Battus tuberculatus* of Kloden among the *Entomostraca*, in a genus which he names Beyrichia, and defines as follows:

"Gen. Char. Shell bivalve, rotundato-quadrate, ventral margin slightly concave, ends very nearly equal, obtusely rounded; sides equal, very gibbous, deeply impressed by a strong and wide sulcus, which extends from the ventral margin nearly to the dorsal, giving a bilobed or reniform appearance to each valve; sulcus slightly nearer to the anterior end; within this sulcus on each valve, and close to the anterior (or smaller) side, is a lengthened oval tubercle, nearly at right angles with the ventral margin, and reaching about two thirds of the distance from thence to the dorsal margin; surface smooth.

"On first examining some specimens from the Irish Silurian sandstones, of what I considered to be the *Agnostus* (*Battus*) *tuberculatus*, Klod., of the Silurian System, I perceived that the vertical sulcus was very slightly nearer to one end than to the other, and that the lengthened tubercle forming the so-called mesial lobe was not precisely in the middle, as figured and described by authors; this deviation, though very slight, was important, as showing that we could not be really looking at the back of a symmetrical animal, as was previously supposed, and that the creature could not be an *Agnostus*. I also perceived that some of the specimens had the tubercle nearest the right, and others nearest the left end, and that consequently I had got the two valves of an entomostracous shell. I therefore doubted the correctness of the reference to the English species until, on examining the original specimens in London, I found that they too were unsymmetrical; I am now therefore certain that my observations apply equally to the Irish fossil and the *Agnostus tuberculatus* of Wales, but should still have doubted the reference to Kloden's Brandenburg species, had not an author well acquainted with the continental fossil published, a few months ago, a Memoir, in which he incidentally alludes to this subject, and expresses an opinion of Klöden's

continental fossil, similar to that I had already formed of the English and Irish specimens, and which though I cannot advance as a discovery, I can yet confirm so far. To give Herr Beyrich full credit for his penetration, I subjoin his remarks (loc. cit. p. 47), and have great pleasure in naming the genus after him. '*Battus tuberculatus*, Klöden, welchen Burmeister als synonym zu *Odontopleura orata* citirt, ist weder ein Battus noch überhaupt ein Trilobit. Er hat ein zweiklappige Schale, deren Oberfläche mit ganz unsymmetrisch geordneten Lappen und Tuberkeln bedeckt ist, und muss eine besondere Gattung neben *Cytherina* bilden.'

"The *Agnostus latus* of the American geologists from their 'Clinton group,' also belongs to this genus. The species I propose naming after its original discoverer, *Beyrichia Kladeni*." (Loc. cit. p. 58.)

The *Cythere phaseolus* of Hisinger is enumerated among Irish Silurian fossils in the same work.

IV. The following new Trilobites and Entomostraca are described and figured by Mr. Salter in the work of Professor Sedgwick, already mentioned.*

Illænus Davisii.
Bowmanni.
Asaphus elevatus.
Homalonotus bisulcatus.
rudis.
? Cephalaspis.
Dalmannia affinis.
obtusicaudata
Phacops apiculatus
felinus.
alifrons.
Cheirurus juvenis.
Cybele sexcostata.
Calymene tuberculosa.
parvifrons.
Lichas (nodulosus)
Ogygia radiata.
Agnostus trinodus.
Beyrichia complicata.
Beyrichia plicata.
Cythere umbonata.
Cypridina strangulata.

V. From the treatise 'Ueber einige böhmische Trilobiten,' by Dr. Ernst Beyrich (1845), referred to by Professor Burmeister more than once, we have extracted the following generic characters of CHEIRURUS, SPHÆREXOCHUS, LICHAS, and TROCHURUS.

CHEIRURUS. Caput ambitu semi-orbiculari, limbo præcinctum, testa tectum granulosa in glabella, scrobiculosa in genis. Suturæ faciales ab oculis postice ad marginem exteriorem, antice sejunctæ ad marginem ductæ. Oculi parvi. Sulcus occipitalis profundus, prope angulos cum sulco marginali confluens. Glabella magna, lata, usque ad limbum marginalem porrecta, frontem versus dilatata. Sulci laterales glabellæ tres distincti; posteriores versus ad sulcum verticalem retrorsi: medii et anteriores sæpius conjuncti, recti vel parum retroversi. Alæ occipitales scuti centralis latæ; scuta marginalia parva.

Thorax ex articulis undecim. Rhachis arcuata, versus pygidium coarctata, transversim annulata. Pleuræ sulco transversali in partem interiorem minorem et exteriorem

* In the forthcoming (the second) volume of the Memoirs of the Geological Survey of England and Wales, now in the press, a new species of *Olenus* is described by Professor Phillips, under the name of *O. humilis*, and a new *Ampyx*, named by Professor E. Forbes, *A. parvulus*.

majorem divisæ; pars interior sulco longitudinali obliquo exarata, pars exterior integra recurva.

Pygidium breve, latum, digitato-fissum, compositum ex articulis tribus completis et articulo quarto terminali pleuris carente. Pleuræ majore ex parte liberæ; anteriores sulco brevi longitudinali exaratæ æque ut thoracis pleuræ.

(Three new species, *C. insignis*, *C. claviger*, and *C. gibbus*.)

Sphærexochus. Caput ambitu semi-orbiculari (limbo præcinctum?) testa tectum undique granulosa. Suturæ faciales ab oculis postice ad marginem exteriorem prope angulis, antice sejunctæ ad marginem ductæ. Oculi cornea rotundata distinctæ granulosa (Loven.) Sulcus occipitalis latus profundus. Glabella magna, antice usque ad marginem producta, inde a sulco verticali turgida, subhemisphærica. Sulci laterales omnes sejuncti, posteriores reversi, sæpius cum sulco verticali confluentes; anteriores et medii recti, sejuncti, sæpius obscuri.

Thorax ex articulis undecim.

Pygidium breve, latum, digitato-fissum, compositum ex articulis tribus completis, quorum postremus in rhachi penitus implicatus est cum articulo terminali. Pleuræ elevatæ; sulcis profundis sejunctæ, apicibus liberis.

(*Sphærexochus mirus.*)

Lichas. Caput testa tectum undique dense granulosa. Suturæ faciales ab oculis antice sejunctæ ad marginem ductæ; postice (?) Glabella lata usque ad marginem porrecta, fronte plerumque tumida margini imminente. Sulci laterales anteriores retroversi, longissimi, sejuncti proxime ad sulcum verticalem retroducti; medii sæpius obsoleti, posteriores breves, retroversi, cum sulco verticali confluentes.

Thorax ex articulis undecim, pleuris planis, falcatis, sulco longitudinali usque ad apicem acutum exaratis.

Pygidium ambitu laciniato, compositum ex articulis tribus completis, quorum postremus in rhachi obscure distinctus est a medio et penitus implicatus cum articuli terminali. Pleuræ sulcis sejunctæ et sulcis longitudinalibus exaratæ, apicibus anteriorum et mediarum (in quibusdam speciebus posteriorum quoque?) liberis.

(Two new species, *Lichas scabra* and *L. dissidens*.)

Trochurus. Caput ambitu semi-orbiculari, testa tectum undique granulosa. Suturæ faciales ab oculis postice ad marginem exteriorem prope angulos ductæ; antice? Oculi? Glabellæ pars anterior (frons) valde dilatata, turgida, subhemisphærica, usque ad marginem porrecta; pars posterior angusta, semicylindracea, sulcis dorsalibus parallelis definita, stipitem quasi frontis exhibens. Sulci laterales posteriores et medii obsoleti, anteriores conjuncti; sulcus occipitalis profundus.

Thorax ex articulis undecim?

Pygidium ambitu semi-orbiculari; lateribus planis; rachi convexa, versus marginem angustata et attenuata; margine spinis sex tenuibus pendulis aucto. Rhachis antice annulos articulorum duos præbet, sulcis profundis sejunctos. Pleuræ utrinque tres distinguendæ; anteriores et mediæ costis definitæ, rectis, radiantibus, ad spinas marginis ductis; posteriores costis carentes, cum rhachi coalitæ, prope rhachim spiniferæ. Testa granulis inæqualibus scabra.

(One species *Trochurus speciosus*.)

VI. M. Joachim Barrande has very recently (1846) published a memoir, entitled

'Notice Préliminaire sur le Système Silurien et les Trilobites de Bohême.' In this paper a very great number of new species of Trilobites are briefly described, but not figured, and several new genera noticed. With a view to prevent over-multiplication of synonyms, and to render this enumeration as complete as possible, we extract the new names given in M. Barrande's treatise, and refer the reader to the work itself for the descriptions. In the following list the names of the new genera are printed in small capitals.

ARETHUSA Koninckii
ARION ectiocephalus
Asaphus ingens
nobilis
(Nileus) Bouchardi

Battus bibullatus
granulatus
Orion
affinis
rex
cuneifer
tardus
Bronteus Brongniarti
porosus
pustulatus
formosus
angusticeps
Zippei
Partschii
Haidingeri
ambiguus

CAPHYRA radians
Calymene pulchra
parvula
incerta
diademata
Bayleii
Beaumonti
Cheirurus Beyrichii
Quenstedti
corda
Conocephalus Emmerichii
coronatus
Cyphaspis Burmeisteri
depressa
cerberus

DIONE formosa

EGLE rediviva
Ellipsocephalus nanus
tumidus

Harpes tenuipunctatus

HYDROCEPHALUS Saturnoïdes
carens

Lichas propinqua
palmata
simplex
Haueri
parvus

MONADINA distincta
micron

Odontopleura Prevosti
Dufrenoyi
mira
Verneuili
Leonhardi
minuta
tricornis
direlicta
Hornesii
lacerata
Buchii
primordialis

Proetus Ryckholtii
intermedius
decorus
venustus
lepidus
tuberculatus
Myops
inæquicostatus
sculptus
gracilis
Lovénii
PHAETON membranaceus
striatus
Archiaci
Paradoxides Linnei
rotundatus
pusillus
Phacops fecundus
bulliceps
trapeziceps

Phacops Gloekeri
intercostatus
spinifer
Reussii
Bronnii
socialis
Hawlei
elongatus
dubius
Phillipsii
intermedius
breviceps
Phacops lævigatus

Sao hirsuta
Staurocephalus Murchisoni

Trinucleus Goldfussii
Bucklandii
Trilobites heteroclytus
orbitatus
desideratus
decipiens
Lindaueri.

DESCRIPTION OF THE PLATES.

TABLE I.

Fig. 1. *Trinucleus Caractaci.*
2. *Oggia Buchii.*
3. *Guettardi.*
4. *Odontopleura elliptica.*
5. *Paradoxides bohemicus*, old specimen.
6. *Do.* *do.* young.
7. *Do.* *do.* under part of cephalic shield (*bucephalus*).
8. *Ellipsocephalus Hoffii.*
9. *Conocephalus striatus.*
10. *Sulzeri.*
11. *Harpes ungula.*
11*a*. A portion of the sculpture of the margin magnified.

TABLE II.

Fig. 1. *Calymene Blumenbachii*, rolled up, viewed from the side, drawn from a perfectly-preserved specimen in M. E. Anton's collection.
2. The same, extended, seen from above.
3. The same, a front view.
4. *Phacops latifrons*, rolled up, side view.
5. The same, extended, from above.
6. The same, front view.
7. Cephalic shield of *Calymene Tristani*, from above.
8. The same, from the side.
9. Cephalic shield of *Calymene callicephala*, from above.
10. The same, from the side.
11. *Odontopleura ovata.*
12. *Asaphus platycephalus.*

TABLE III.

Fig. 1. *Proetus Cuvieri, Gerastos lævigatus,* Goldf., rolled up, side view.
2. The same, extended, from above.
3. *Cyphaspis ceratophthalma*, rolled up, side view.
4. The same, extended from above.
5. *Aconia diops* (*Calymene diops*, Green).
6. *Phacops protuberans.*
7. *Tril. Sternbergii*, cephalic shield from the side.
8. The same, from above.
9. *Oleanus gibbosus.*
10. *Illænus giganteus.*

TABLE IV.

Fig. 1. *Homalonotus armatus.*
2. *Phacops rotundifrons.*
3. *Phacops proœvus*, cephalic and caudal shield.
4. *odontocephalus*, head.
5. *conophthalmus.*
6. The same, rolled up.
7. *Phacops arachnoides.*
8. *stellifer.*
9. *caudatus.*
10. Four body rings of *Homalonotus* as seen in a transverse section.
11. Four body rings of *Calymene* as seen in a transverse section.

Remark.—The anterior smaller segment in these two transverse sections, represents the articular fold; the posterior larger segment indicates the true ring, beneath which the articular fold is hidden when the body is extended. In *Calymene* we merely perceive an acute angle at the place where the two segments meet; in *Homalonotus,* on the other hand, a thick, perpendicularly-descending ridge.

12. The eye of *Phacops latifrons,* without a horny membrane, enlarged to twice its natural size.

TABLE V.

Fig. 1. *Asaphus expansus.*
a. Extended.
b. Rolled up, and seen in front.
c. Do. lateral view.
2. *Illænus crassicauda.*
a. Extended.
b. Rolled up, front view.

Fig. 2. *c*. Rolled up, side view.

Remark.—Particular attention has been paid to the sculpture in both figures, and the body has therefore been represented only in outline.

3. *Archegonus claviceps*.
4. Caudal shield of *Isaphus Tyrannus*.
5. *Aeonia Stokesii*, cephalic shield.
6. *Agnostus pisiformis*, cephalic shield.
7. The same, caudal shield.
8. *Aeonia concinna*.
9. *Aeonia verticalis*, *Gerastos cornutus*, Goldf.
10. *Phacops Hausmanni*.

Remark.—Two forms of the caudal shield of this species occur in the grauwacke limestone of Bohemia, of which the one, which is the rarer species, is more elongated, and has 21 joints of the axis, upon which two larger tubercles are placed near the centre. The lateral lobes, 15 in number, are broader, more depressed at the upper part, less distinctly impressed longitudinally, and the granulation of the surface is more scattered. The other form (represented here) is shorter, broader, and more obtuse; has only from 18 to 19 rings in the axis, and 13 more convex and narrower lateral ribs, which are distinctly furrowed at the angle, and very finely, and, on the axis, uniformly granulated. I suspect that the former form may have been the *male*, the latter the *female* individual.

TABLE VI.

Fig. 1. *Apus caneriformis*, viewed from below, natural size, very old.
2. *Serolis paradoxa*, from above, full grown.
3. *Branchipus stagnalis*, from below, enlarged to six times its diameter.
4. Structure of the eyes of *Branchipus*.
   a. Cornea extern. laevis.
   b. Cornea areolata.
   c. Lens.
   d. Corpus vitreum.
   e. Commencement of the black pigment.
   f. Nervus opticus.
5. Parts of the mouth of *Apus*.
   A. The jaw.
   B. 1 P. The accessory parts of the mouth.
   C. 2 P. Do. do.
   D. Rudiment of the first foot.
6. Parts of the mouth of *Branchipus*.
   A. The jaw.
   D. Rudiment of the first foot.

Fig. 7. Imaginary transverse section of an *Asaphus*.

a. Lateral lobes of the shell.

b. The gill.

c. The most external fin lobe.

d. Interior do.

8. View of an *Asaphus corniger us*, from below.

a. Clypeus.

bb. Lobi antennigeri.

cc. Lobi laterales.

d. Labrum.

ee. Mandibulæ.

ff. The indentations into which the lower ends of the lateral lobes are placed when the animal rolls itself up.

h. Rectum.

9. Foot of an *Apus cancriformis*, from the body region, very much enlarged.

10. Foot of the same species, from the central region of the tail, very much enlarged.

11. The last foot of *Apus cancriformis*, very much enlarged.

12. Foot of *Branchipus stagnalis*, very much enlarged.

The designation of each of the feet is as follows:

A. *Basis*, where it is affixed to the body.

B. Basis interna libera.

1—5 Fin lobes.

K. Gill.

L. Lobe protecting the gill.

I. Second protecting lobe.

13. A young Apus.

a. Small feelers.

b. Large feelers.

c. Jaw.

d. Rudiments of the feet.

14. Young *Branchipus*: parts as in the last.

15. *Limnadia mauritiana*, enlarged.

B. Foot of *Limnadia*, parts as above.

16. *Branchipus*, with a Trilobite shell, viewed from above.

INDEX OF GENERA AND SPECIES

ENUMERATED BY THE AUTHOR.

ERRATA.

Page 5, 11 lines from bottom, *for* Torrubia, *read* Torrubia.
17, note, *for* Triarthrus Breki, *read* Triarthus Beckii.
In the table, p. 34, *for* Crophyropoda *read* Lophyropoda; and *for* Arthrostaca, *read* Arthrostraca, also in note to p. 35.

THE END.

C. AND J. ADLARD, PRINTERS, BARTHOLOMEW CLOSE.

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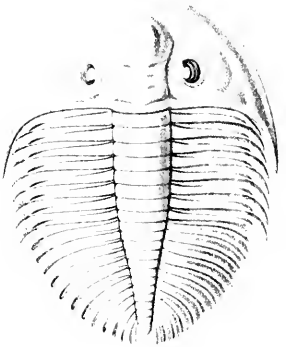

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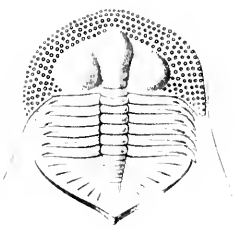

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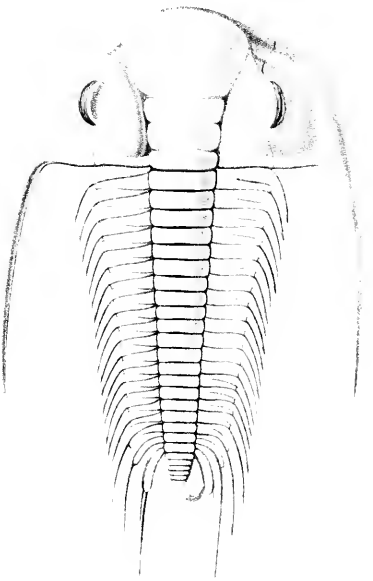

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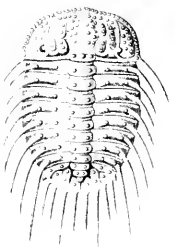

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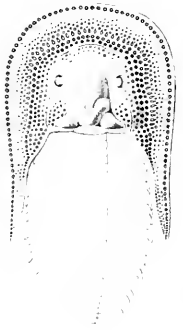

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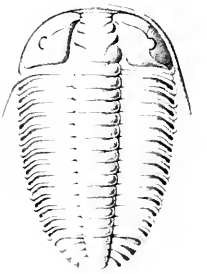

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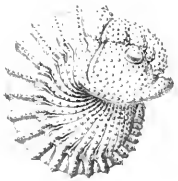

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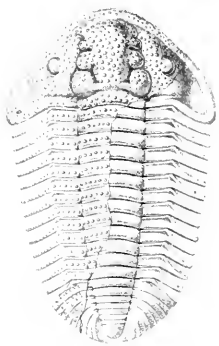

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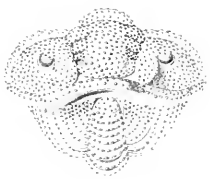

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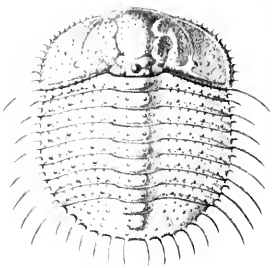

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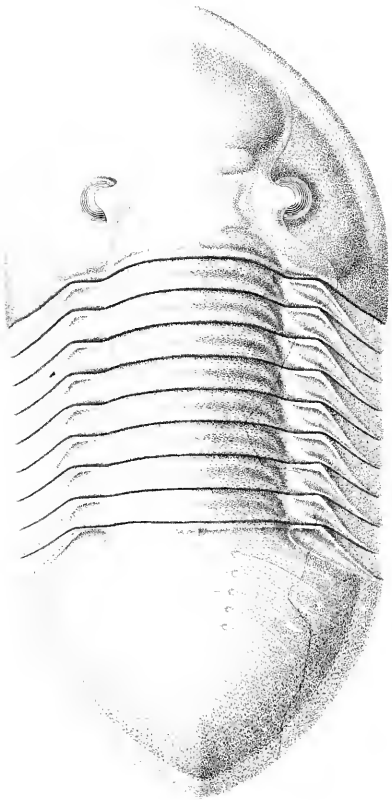

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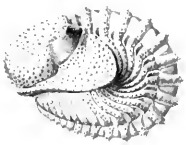

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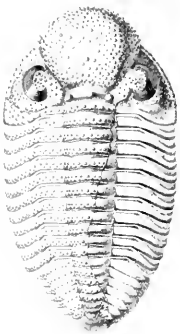

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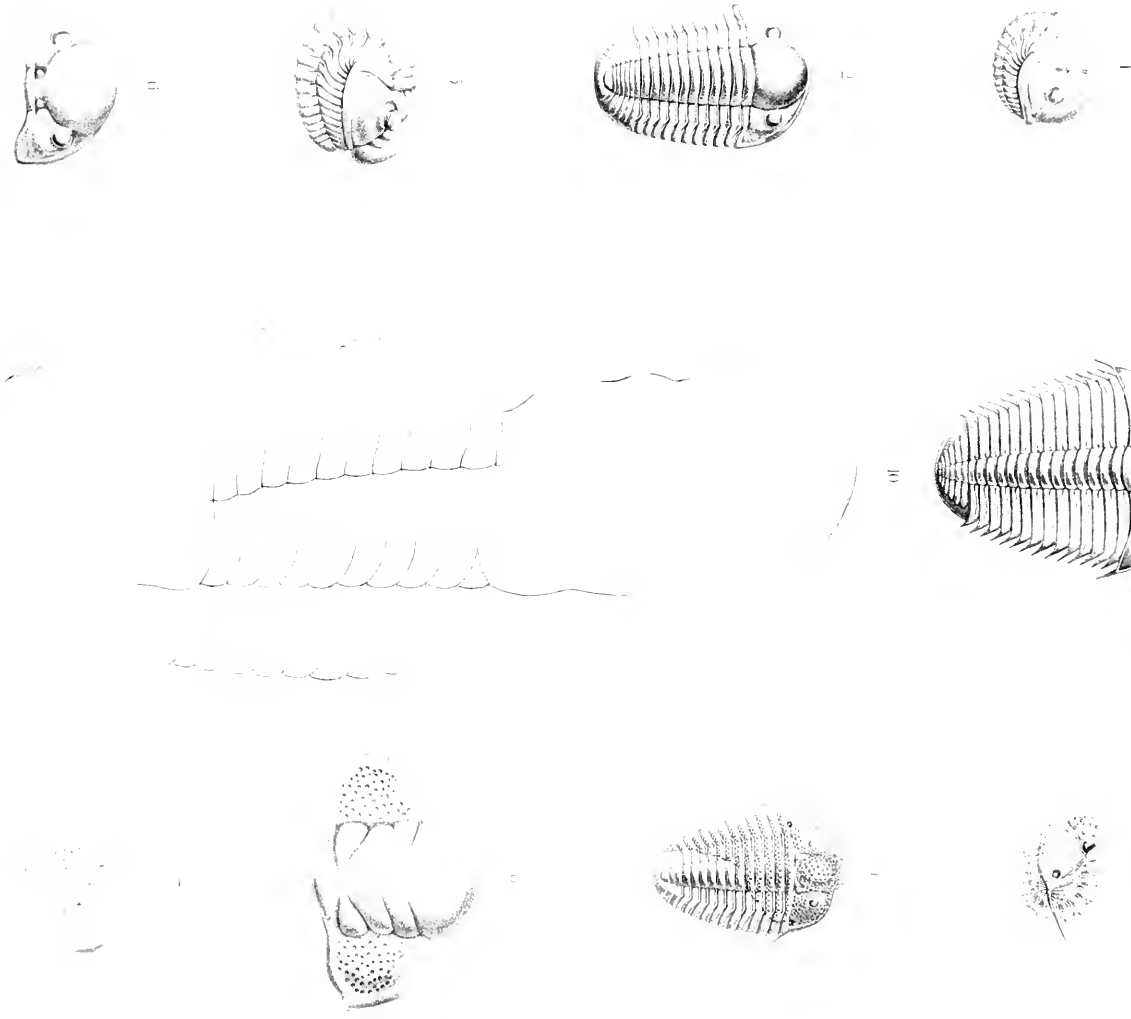

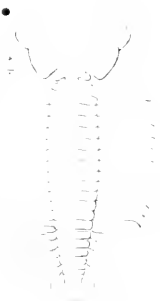

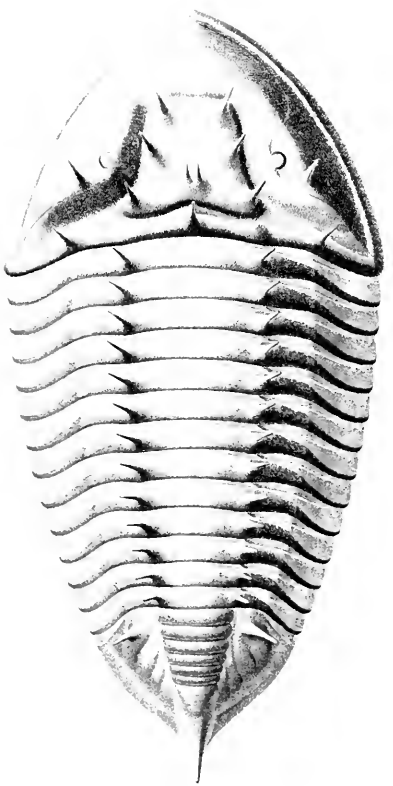

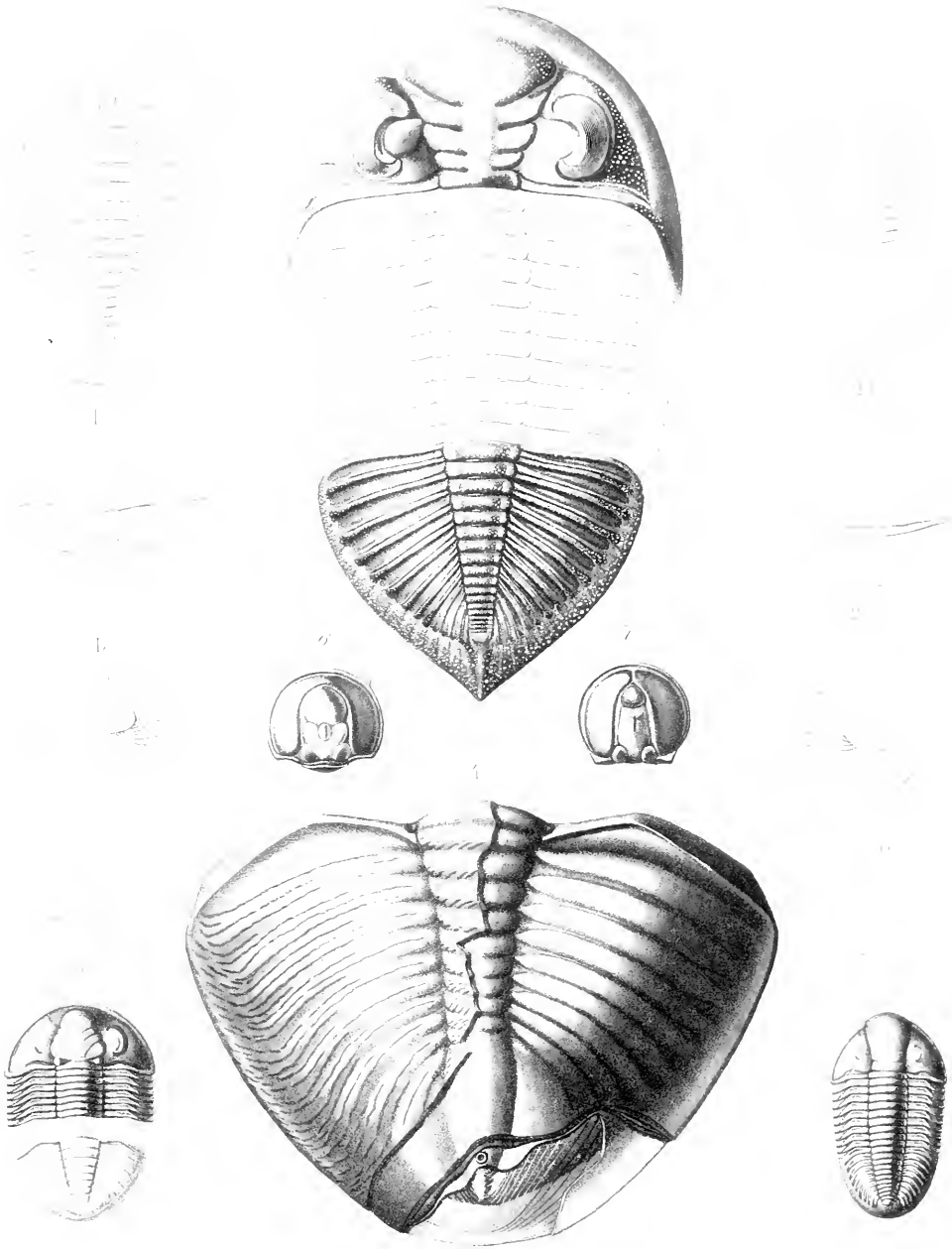

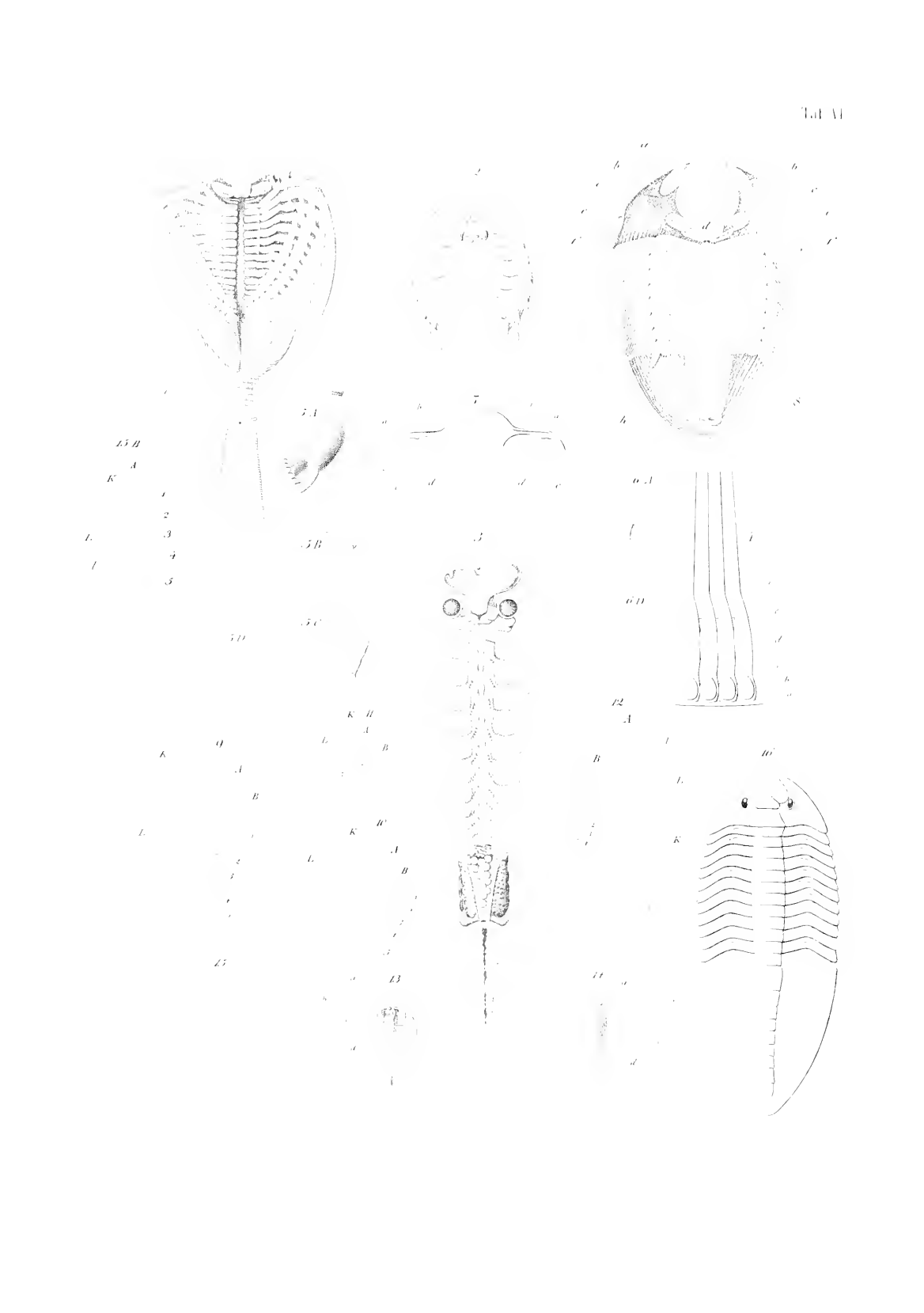

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